



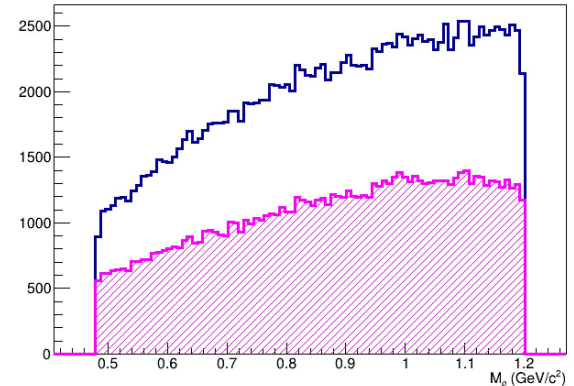
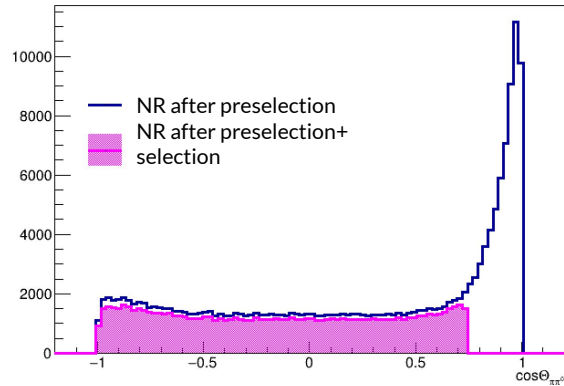
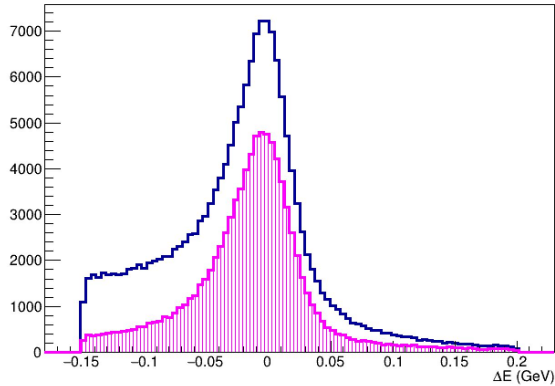

$$\mathcal{B}(B \rightarrow D^0 \rho)$$

TS analysis meeting  
december 2022

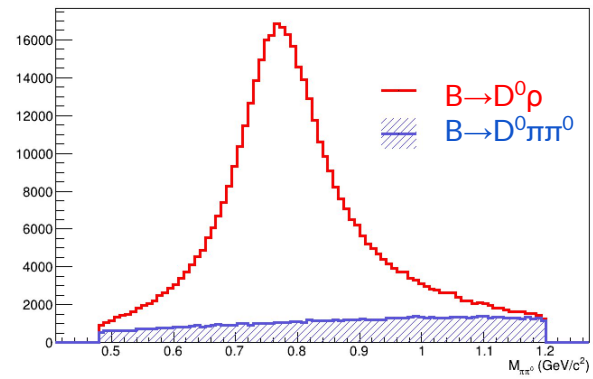
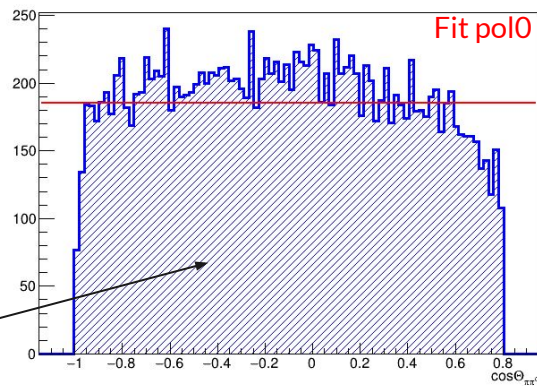
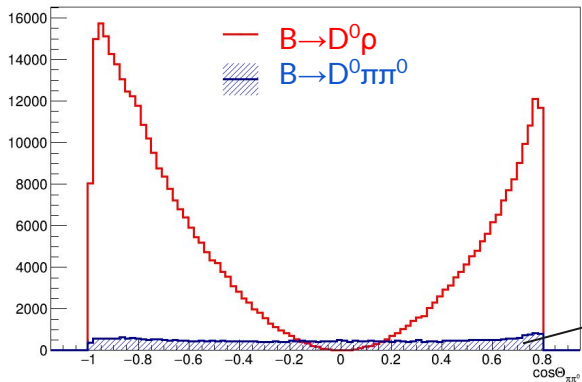
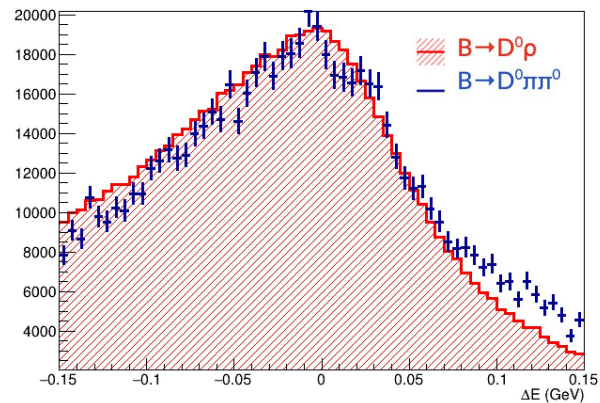
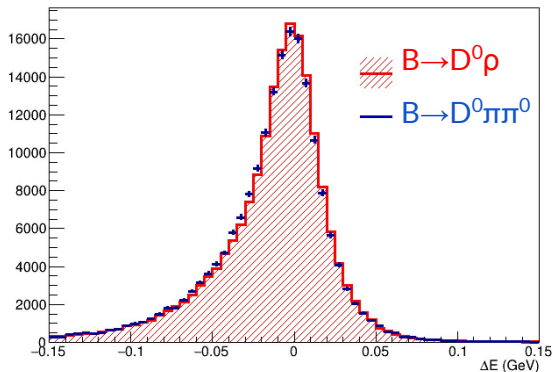
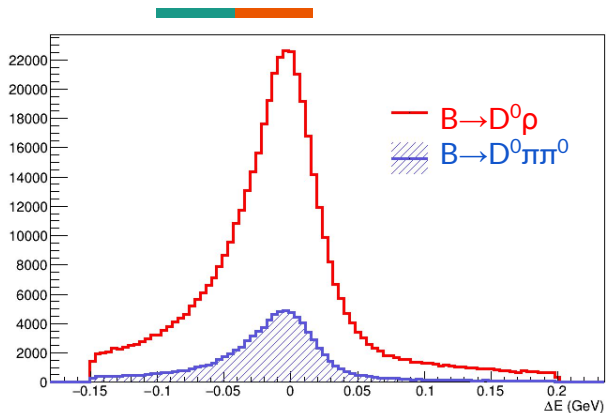
Mirco Dorigo  
Riccardo Manfredi  
Olga Werbycka

# Efficiency for non-resonant decay $B \rightarrow D^0 \pi \pi^0$

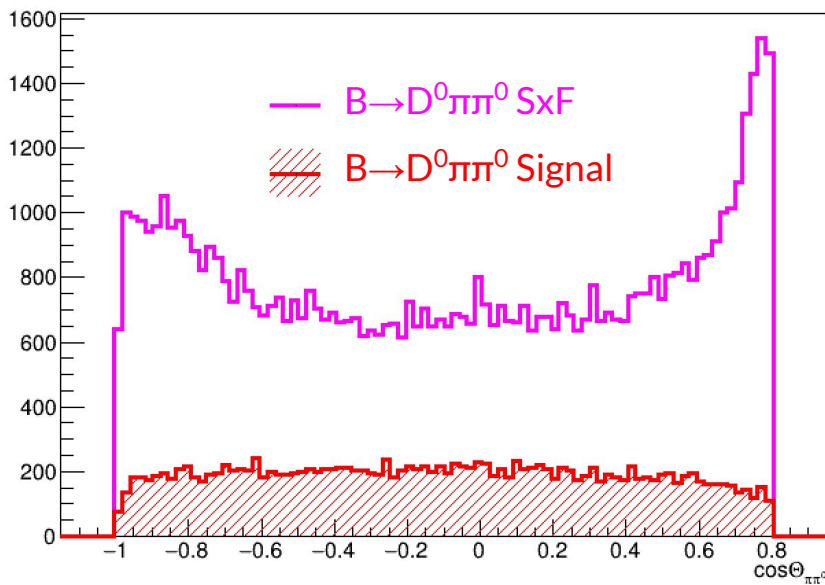
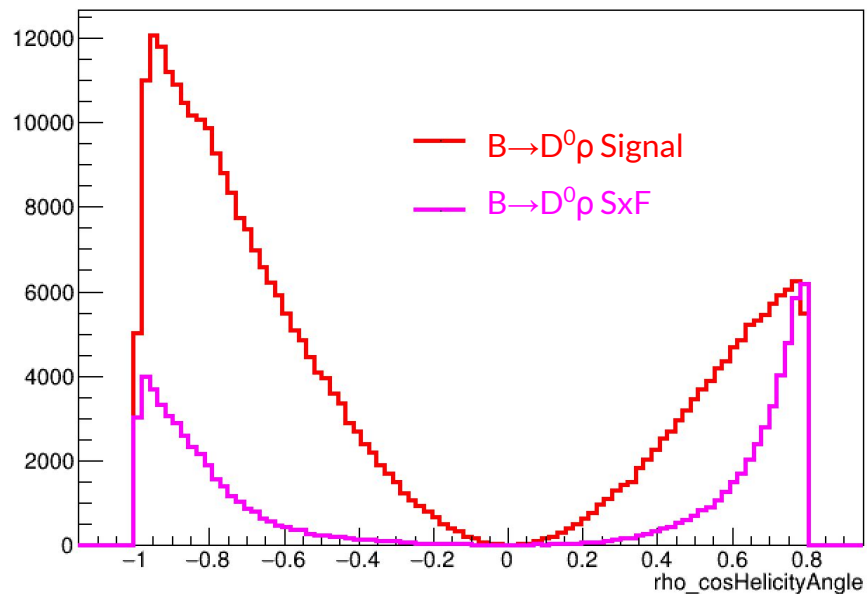
|                       | After<br>preselection | After<br>preselection +<br>selection |
|-----------------------|-----------------------|--------------------------------------|
| NR eff ( $\epsilon$ ) | $\sim 8.4\%$          | $\sim 4.5\%$                         |

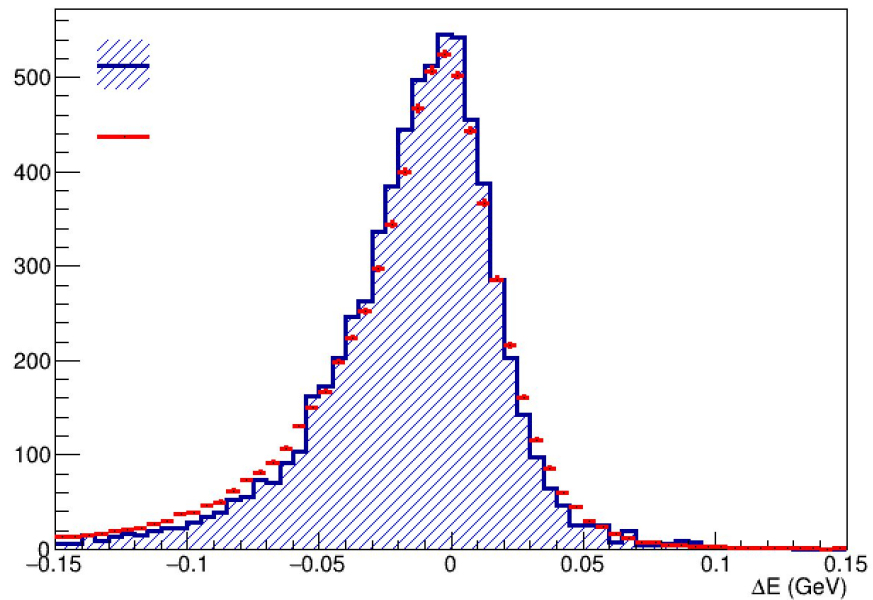
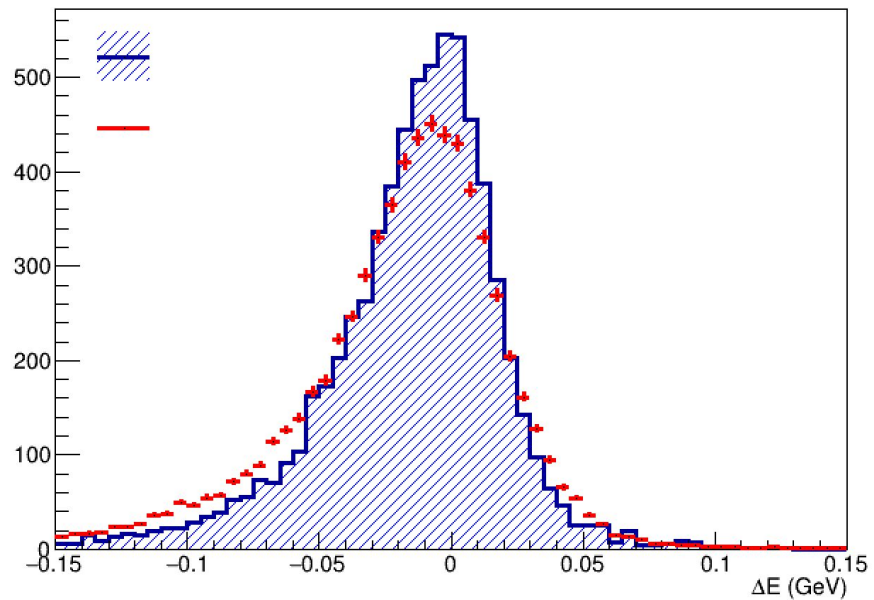


# Comparison of resonant and NR signal MC15 2M events

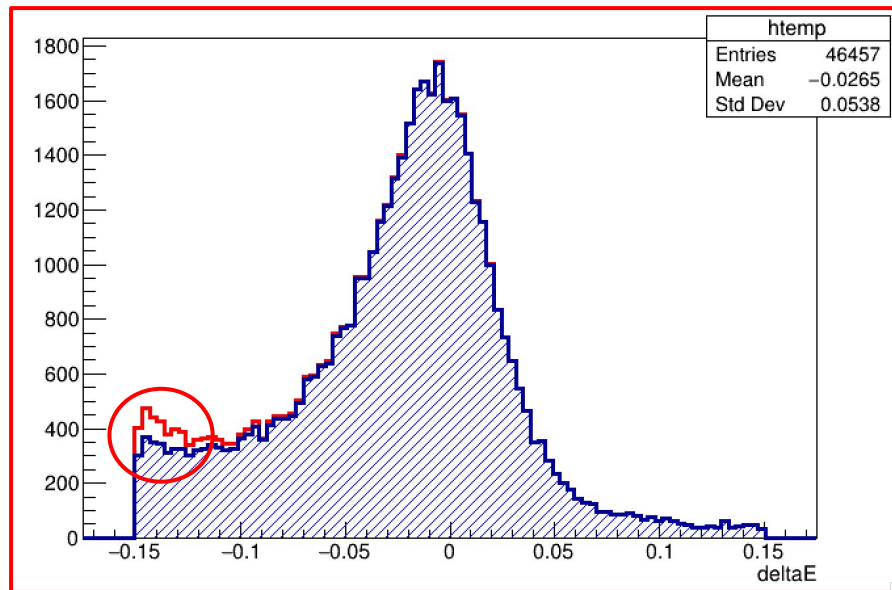


## Signal MC for $D^0\rho$ and $D^0\pi\pi^0$ after full selection



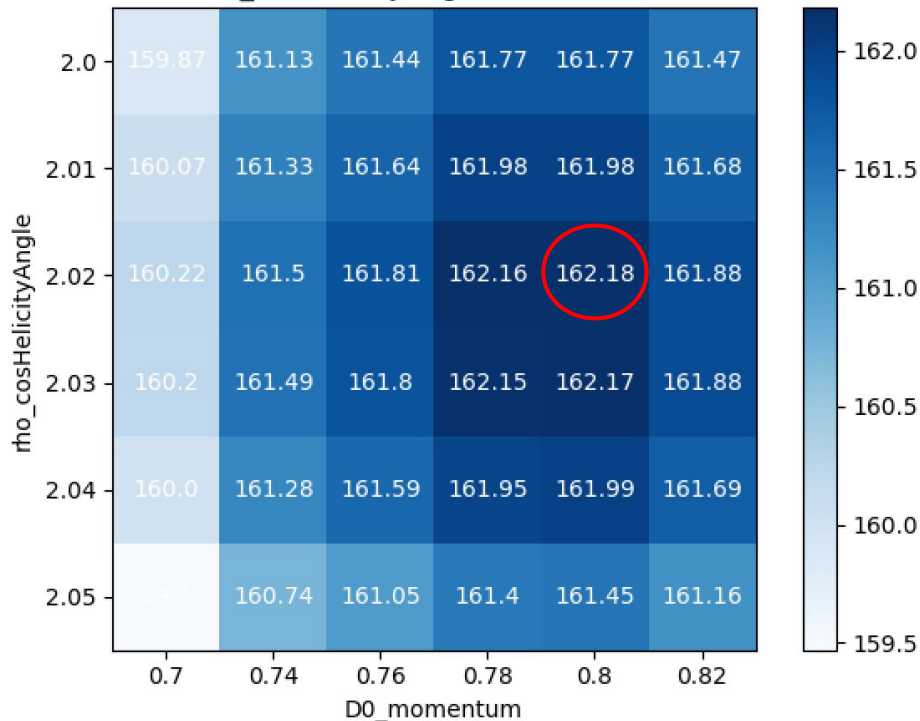


# FOM optimization of $\cos\Theta_{\pi\pi^0}$ vs $D^0$ momentum



$D^0_{\text{mom}}$  cut removes ~1000 events from  $b\bar{b}$ -bar bkg

FOM for  $\text{Rho\_cosHelicityAngle}$  vs low  $D^0$  momentum



## $B^+ \rightarrow D^0(\rightarrow K\pi)\rho$ current selection

Selection applied:

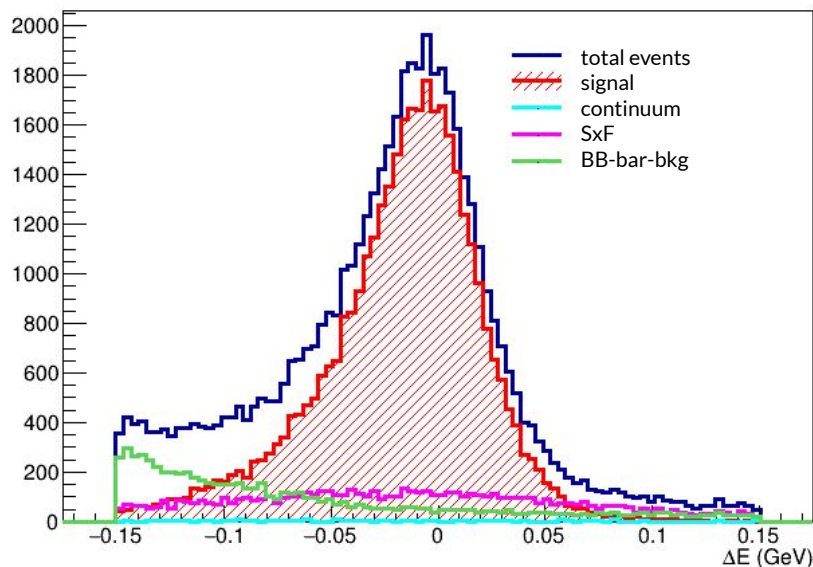
- $M_{bc} > 5.27$
  - $1.84 < M_{D^0} < 1.88$
  - $CSMVA > 0.98$
  - $E_{\text{photon}0} > 0.04$
  - $E_{\text{photon}1} > 0.04$
  - $D^0_{-\pi_{PID}} > 0.2$
  - $D0mom > 2.02$
  - $\cos\Theta_{\pi\pi0} < 0.8$
  - $0.125 < M_{\pi0} < 0.145$
  - $|M_{\rho} - 0.77| < 0.15$
- will be revised

# D<sup>0</sup>ρ composition MC15<sub>ri</sub> 1 ab<sup>-1</sup>

```
# 2-pi
0.013448300 rho+ anti-D0
0.000500000 anti-D0 pi0 pi+
```

SVS; #[BF update - PG 09/2020]

PHSP; #No PDGLive value. Keep original value in .DEC. #[Comment - PG 09/2020]

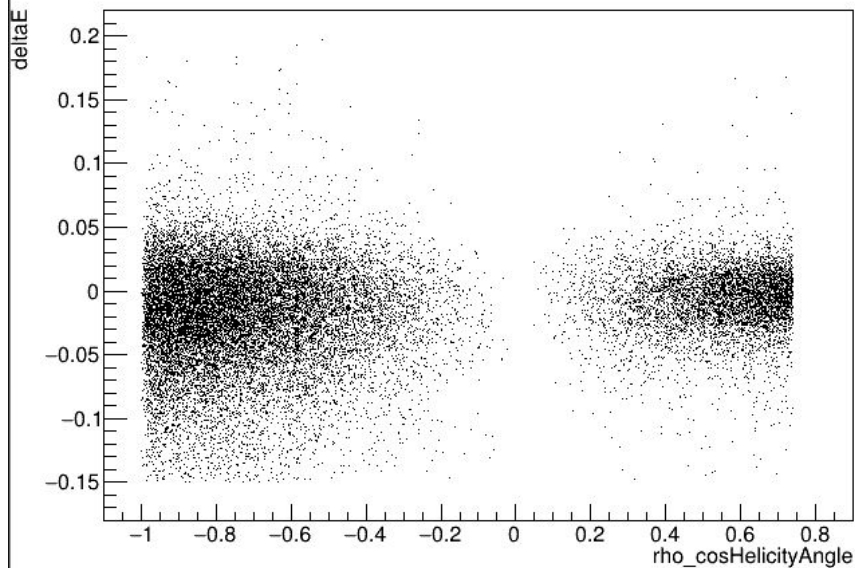


| Composition  | Nevents | Fraction |
|--------------|---------|----------|
| Signal       | 36821   | 0.72     |
| Continuum    | 283     | 0.006    |
| SCF          | 6968    | 0.14     |
| BB-bar bkg   | 7045    | 0.14     |
| Total events | 51119   | 1.0      |

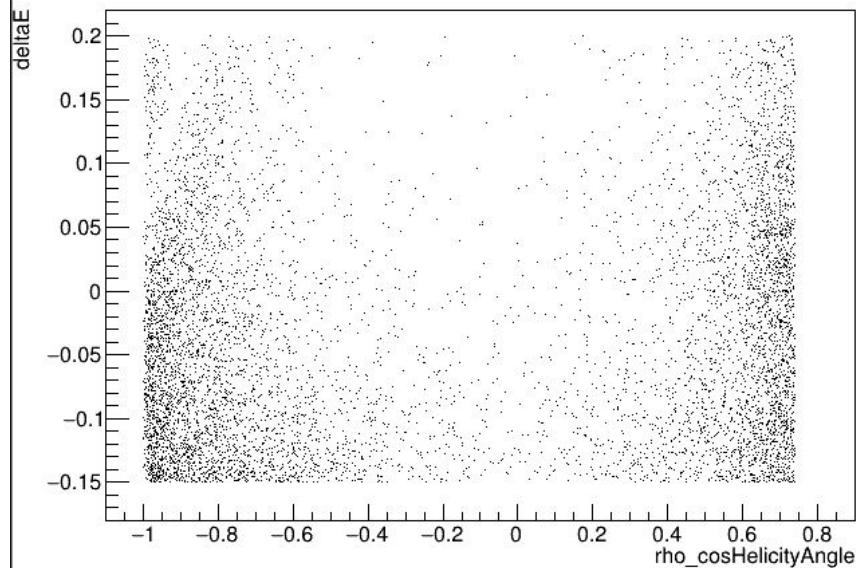
$\cos\Theta_\rho < 0.8$

# Correlations $\Delta E$ vs $\cos\Theta_\rho$

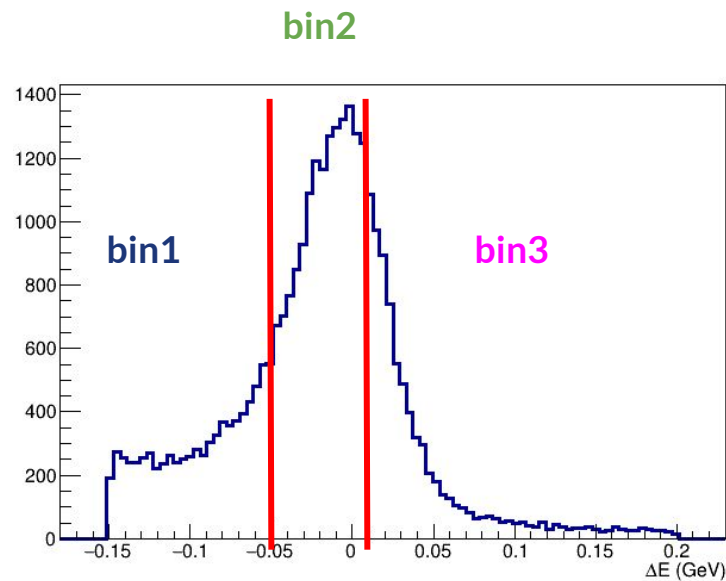
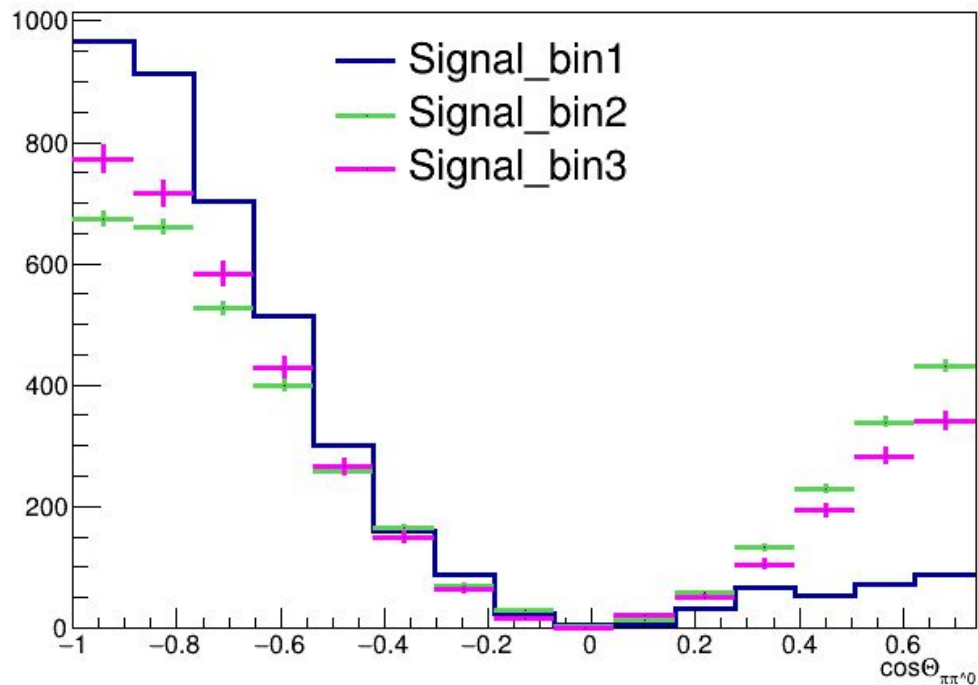
deltaE:rho\_cosHelicityAngle {isSignal==1}



deltaE:rho\_cosHelicityAngle {isSignal!=1}

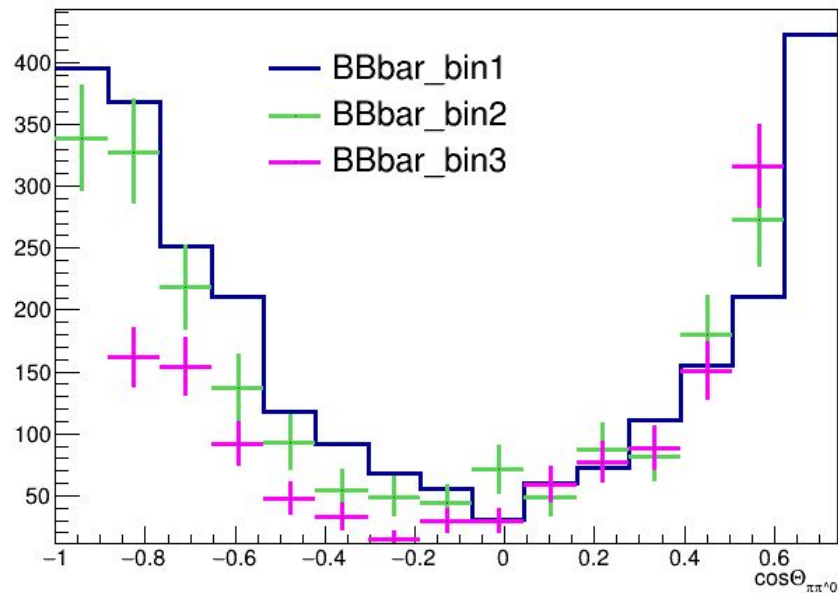
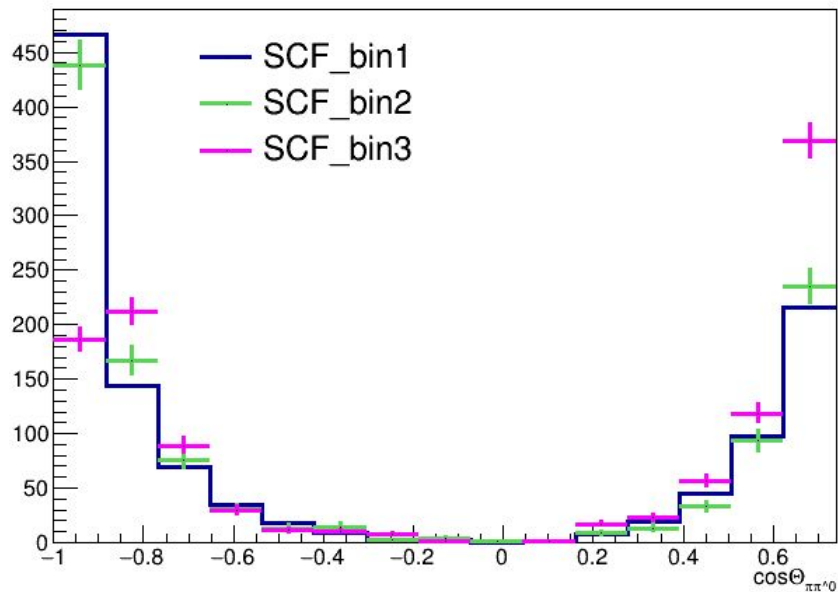


# $\cos\Theta_\rho$ in $\Delta E$ bins for signal

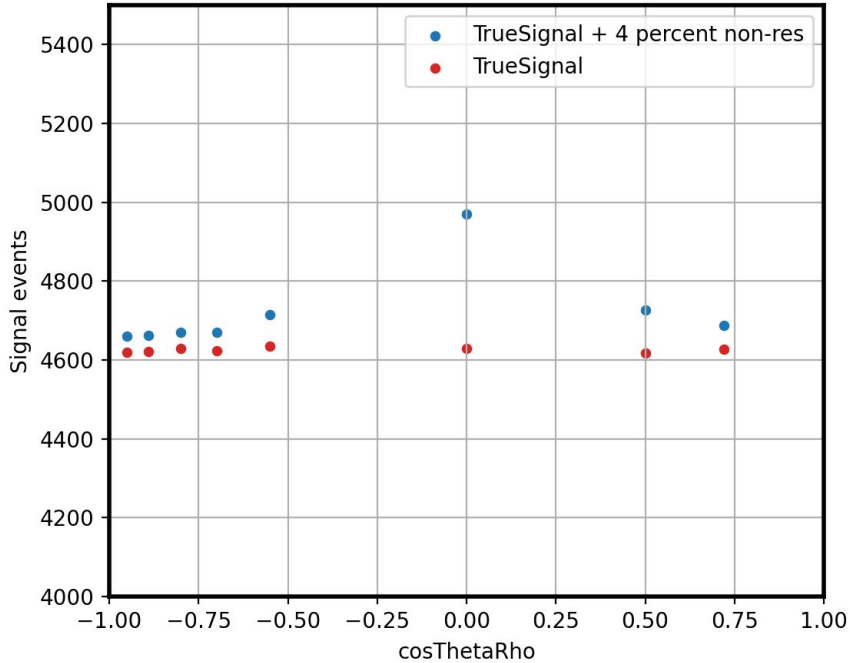


bin choice

# $\cos\Theta_\rho$ in $\Delta E$ bins for SCF and BBbar

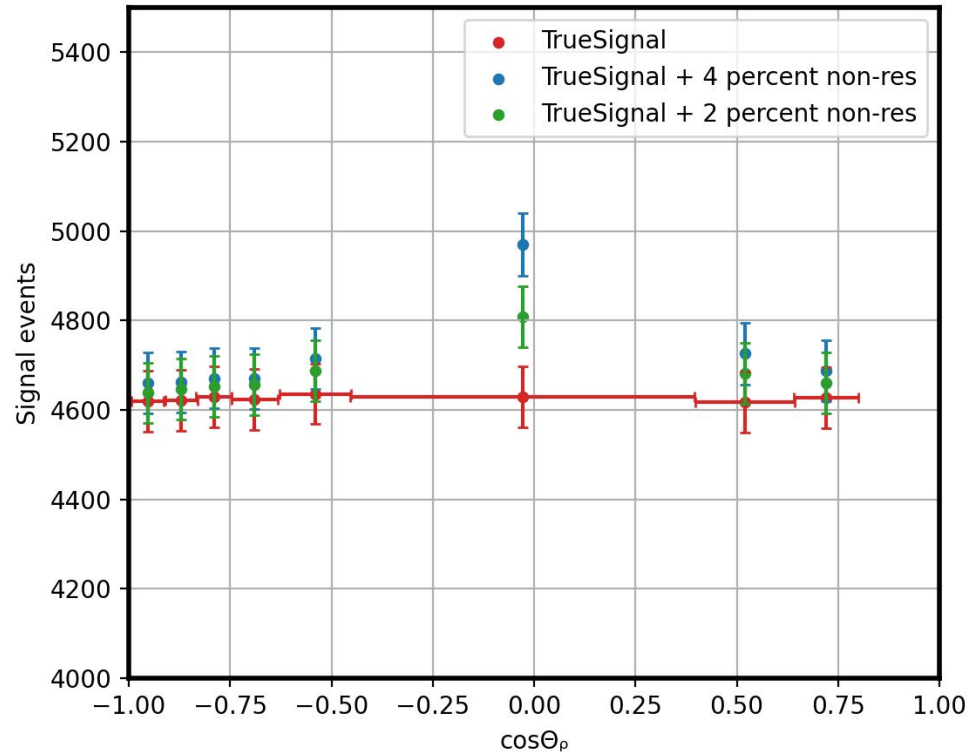


# True signal vs True signal + 4% $D^0\pi\pi^0$

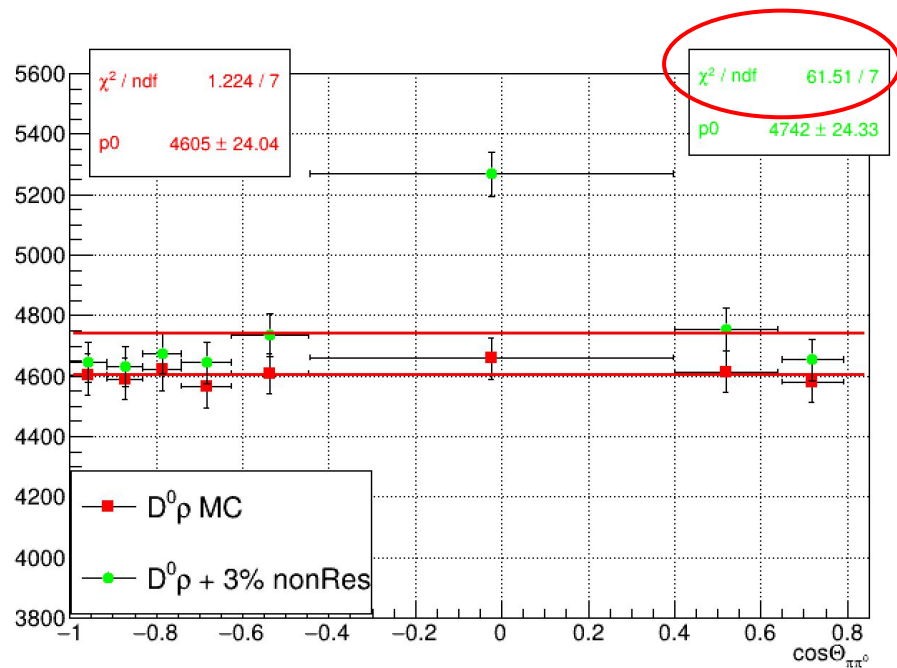
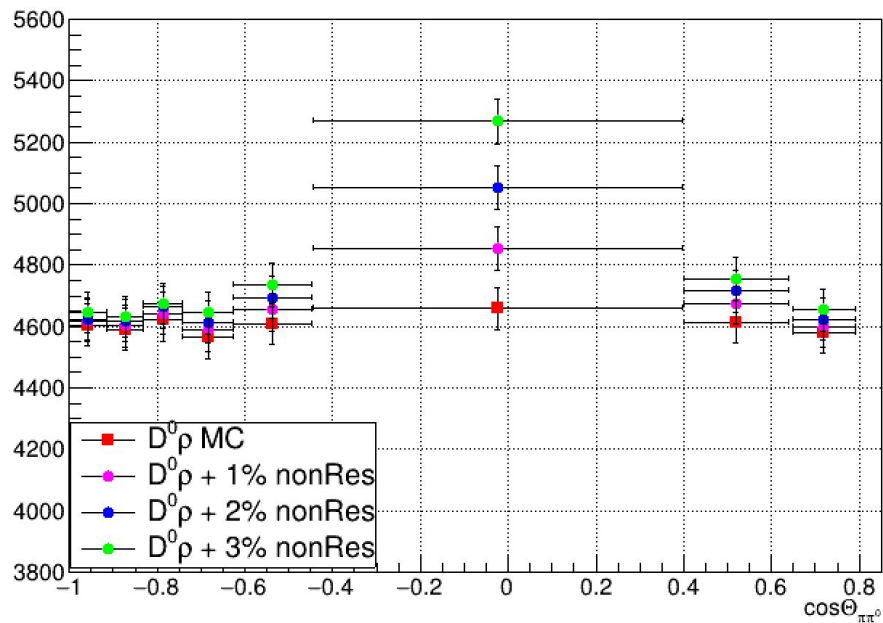


|       | $\cos\Theta_\rho$      | True Sig | Self x-feed | BB-bar |
|-------|------------------------|----------|-------------|--------|
| Bin 1 | $< - 0.914$            | 4620     | 1315        | 662    |
| Bin 2 | $- 0.914 \div - 0.832$ | 4621     | 762         | 500    |
| Bin 3 | $- 0.832 \div - 0.742$ | 4630     | 462         | 492    |
| Bin 4 | $- 0.742 \div - 0.625$ | 4624     | 275         | 484    |
| Bin 5 | $- 0.625 \div - 0.448$ | 4636     | 185         | 456    |
| Bin 6 | $- 0.448 \div 0.403$   | 4630     | 252         | 1098   |
| Bin 7 | $0.403 \div 0.642$     | 4618     | 938         | 1084   |
| Bin 8 | $0.642 \div 0.8$       | 4627     | 2721        | 2245   |

# True signal vs True signal + 2% and 4% $D^0\pi\pi^0$ (fitted values)

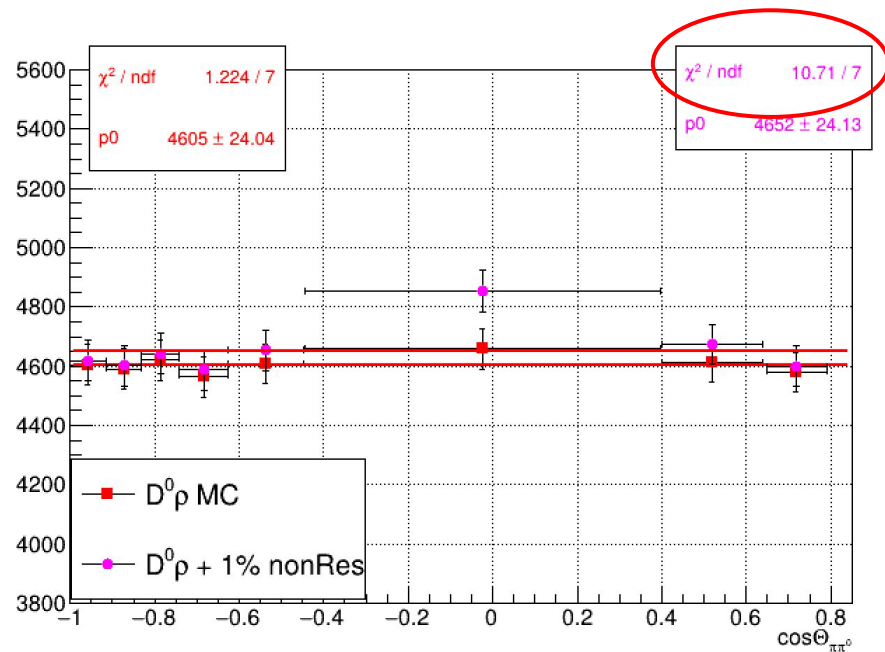
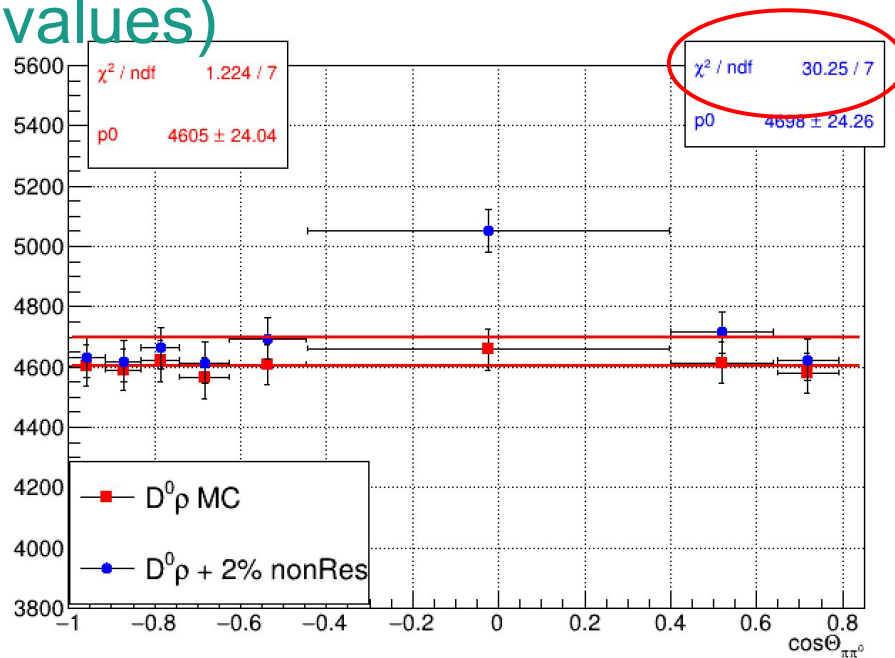


# True signal vs True signal + different contributions of $D^0\pi\pi^0$ added (fitted values)



Fit with  $\text{pol0}$  to  $D\rho$  and ( $D\rho + 3\%$   $D\pi\pi^0$ )

# True signal vs True signal + 2% and 1% $D^0\pi\pi^0$ (fitted values)



Can spot deviations up to 2%  $D\pi\pi^0$  contribution. Need to confirm with toys.

Need to see the effect of interference between  $D\rho$  and  $D\pi\pi^0$ : it should alter the flat expectation too.

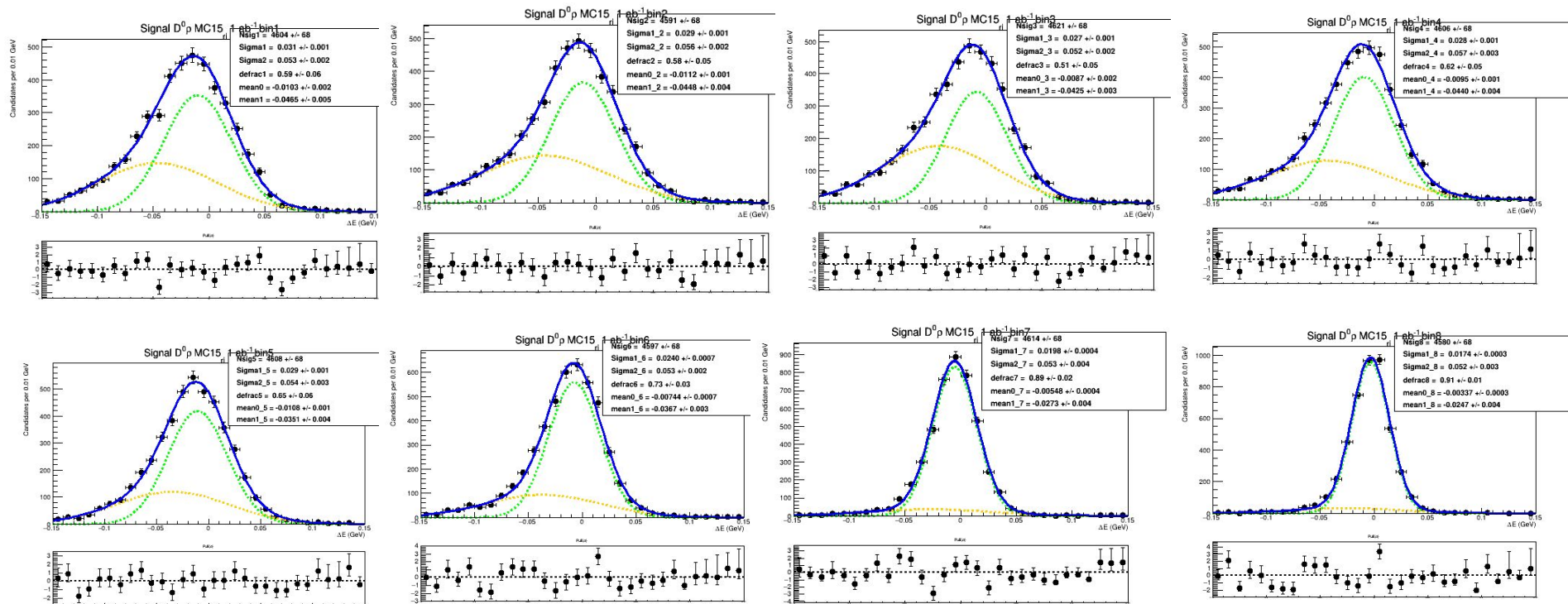
The idea is to make templates of the above distribution for different expected scenario, to be tested against data.

# True components wrt each bin



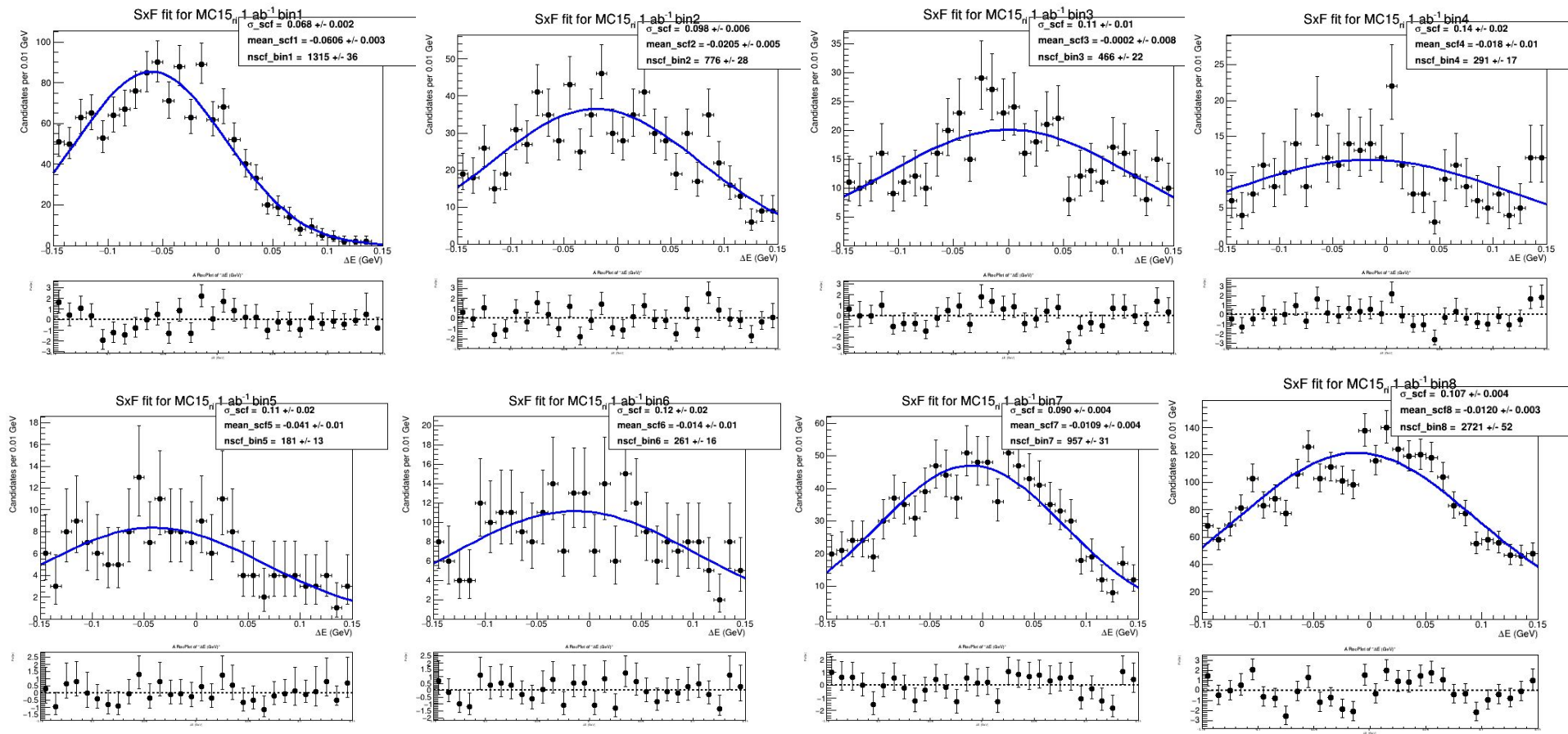
|       | $\cos\Theta_\rho$      | True Sig | Self x-feed | BB-bar |
|-------|------------------------|----------|-------------|--------|
| Bin 1 | $< - 0.914$            | 4604     | 1315        | 642    |
| Bin 2 | $- 0.914 \div - 0.832$ | 4591     | 776         | 481    |
| Bin 3 | $- 0.832 \div - 0.742$ | 4621     | 466         | 490    |
| Bin 4 | $- 0.742 \div - 0.625$ | 4606     | 291         | 459    |
| Bin 5 | $- 0.625 \div - 0.448$ | 4608     | 181         | 443    |
| Bin 6 | $- 0.448 \div 0.403$   | 4597     | 261         | 1073   |
| Bin 7 | $0.403 \div 0.642$     | 4614     | 957         | 1119   |
| Bin 8 | $0.642 \div 0.8$       | 4580     | 2721        | 2338   |

# Signal pure D<sup>0</sup>ρ MC15 fits of each bin

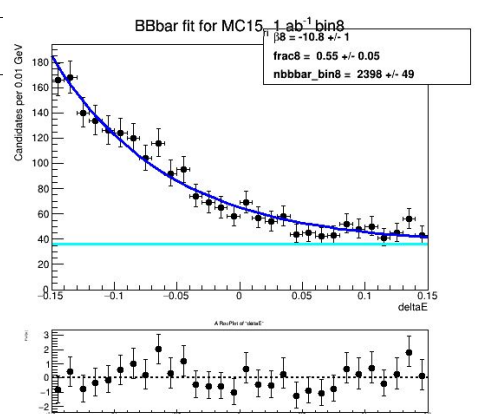
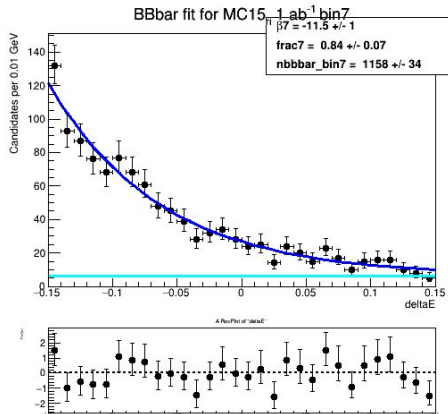
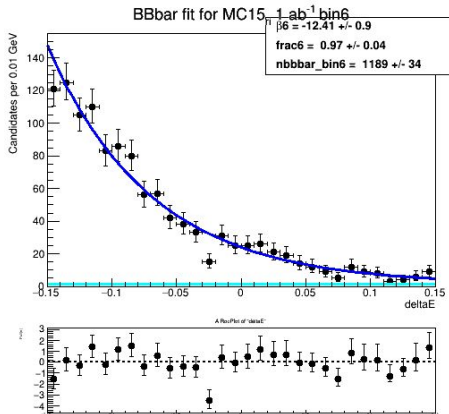
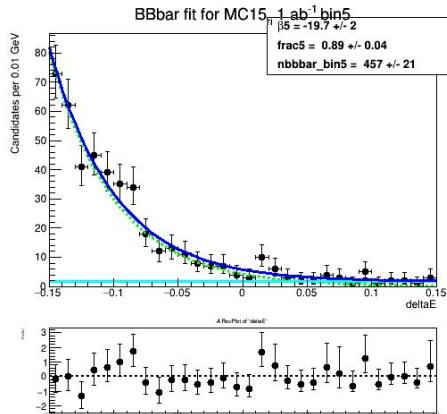
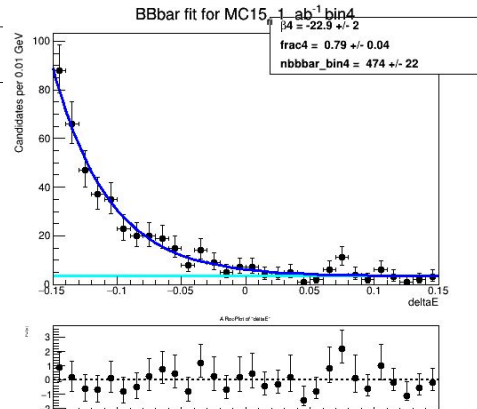
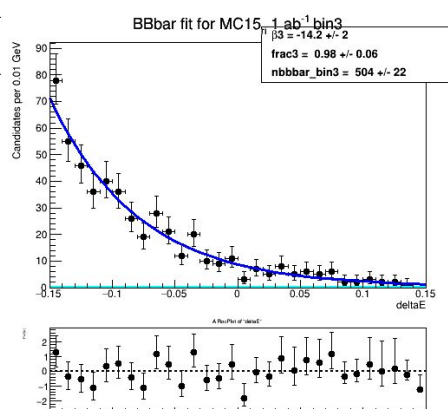
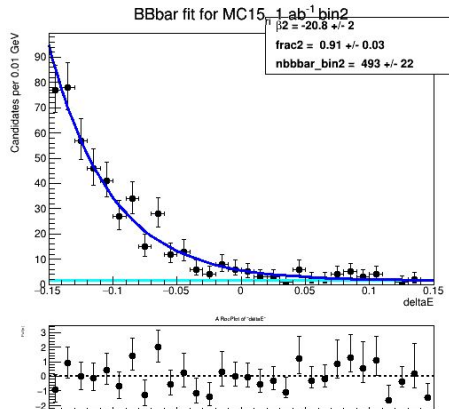
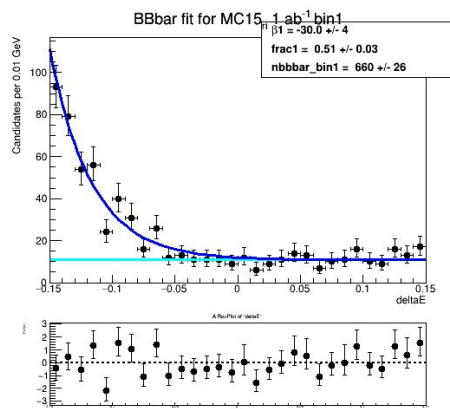


fitted with 2\*Gaussians

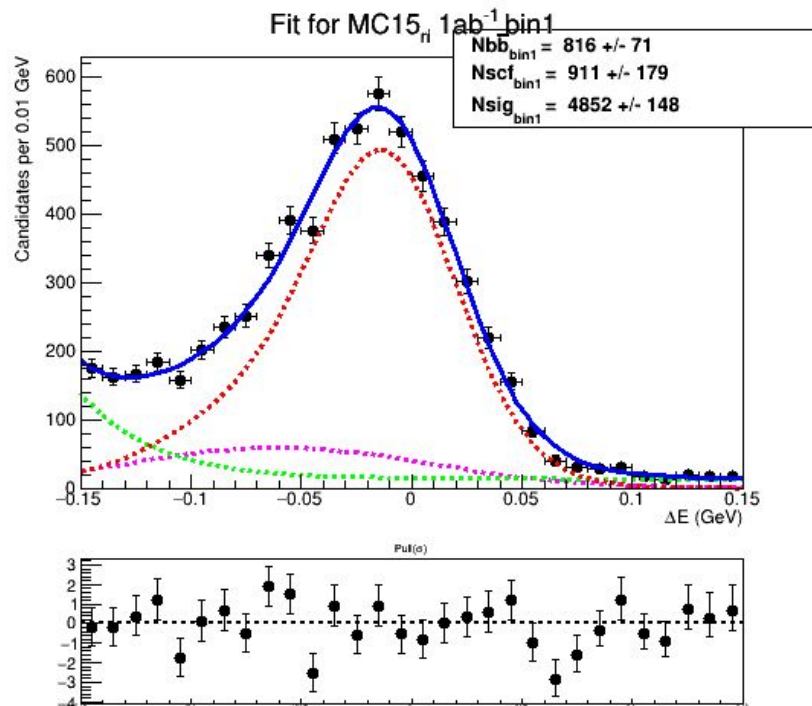
# SxF pure D<sup>0</sup> MC15 fits of each bin



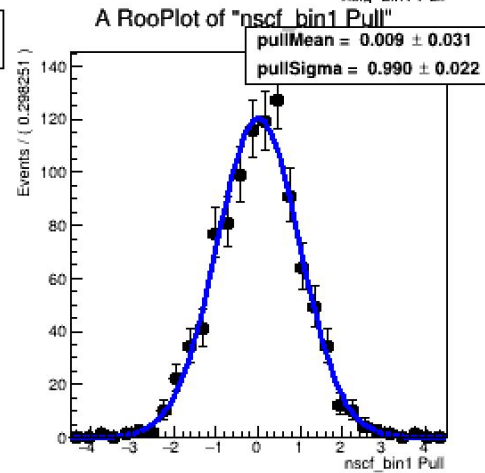
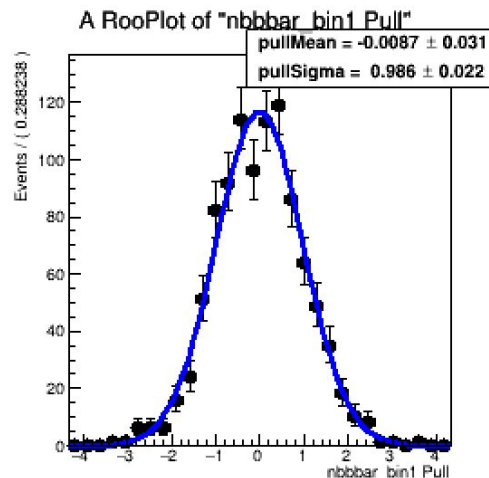
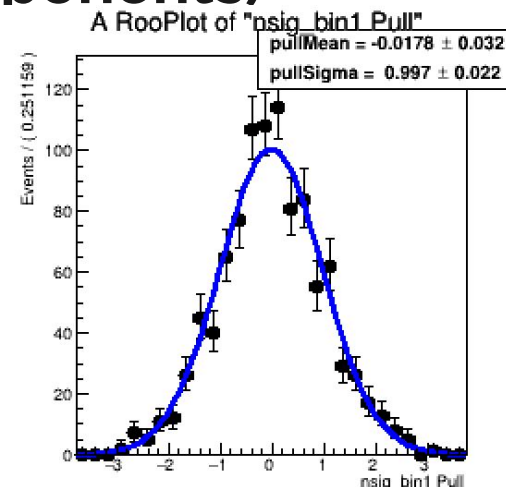
# BB-bar pure D<sup>0</sup>ρ MC15 fits of each bin



# Fit result D<sup>0</sup>ρ MC15 fits for 1 bin (all components)

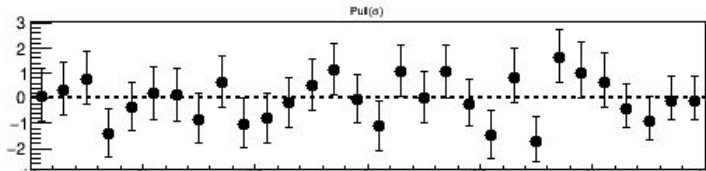
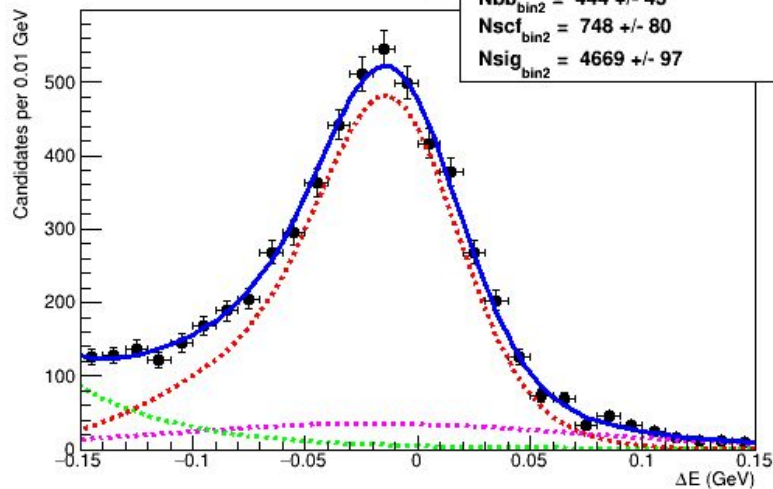


| Composition | σ          |
|-------------|------------|
| Signal      | <b>1.7</b> |
| SxF         | <b>2.3</b> |
| BB-bar      | <b>2.2</b> |



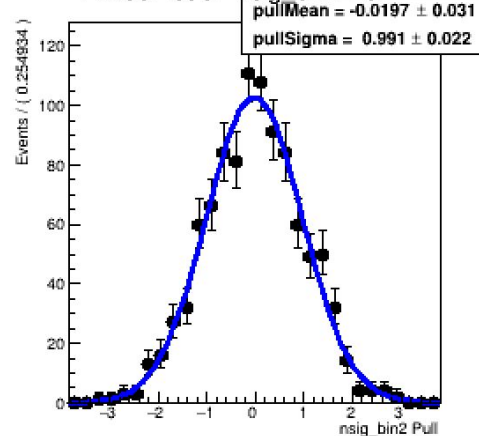
# Fit result D<sup>0</sup>ρ MC15 fits for 2 bin (all components)

Fit for MC15<sub>ri</sub> 1ab<sup>-1</sup> bin2

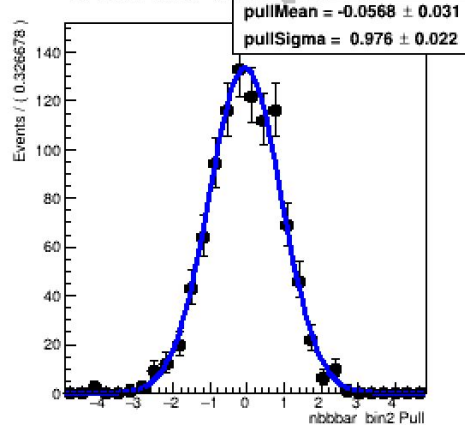


| Composition | $\sigma$ |
|-------------|----------|
| Signal      | 0.8      |
| SxF         | 0.4      |
| BB-bar      | 1.1      |

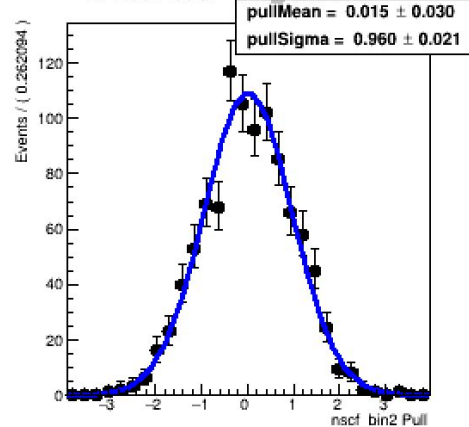
A RooPlot of "nsig\_bin2 Pull"



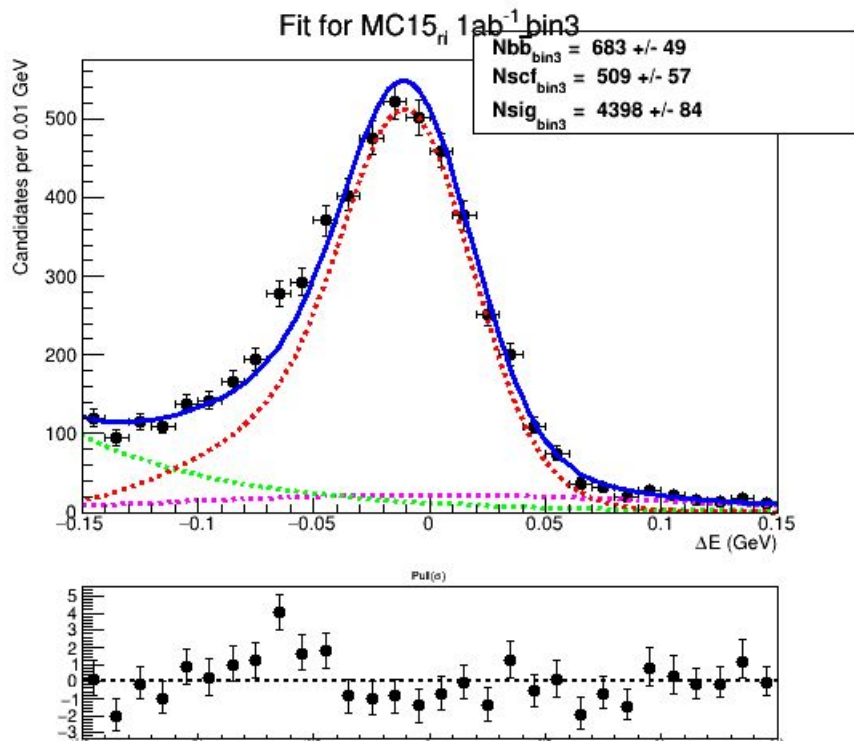
A RooPlot of "nbbbar\_bin2 Pull"



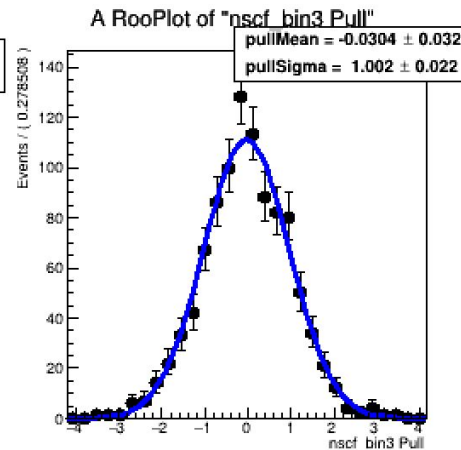
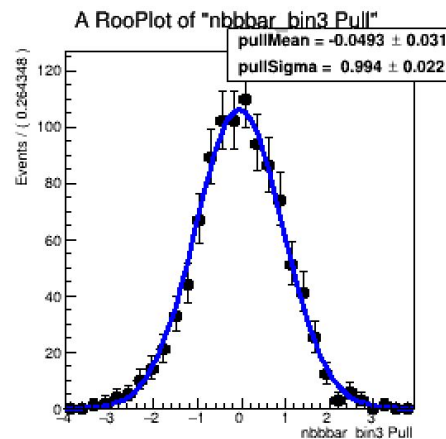
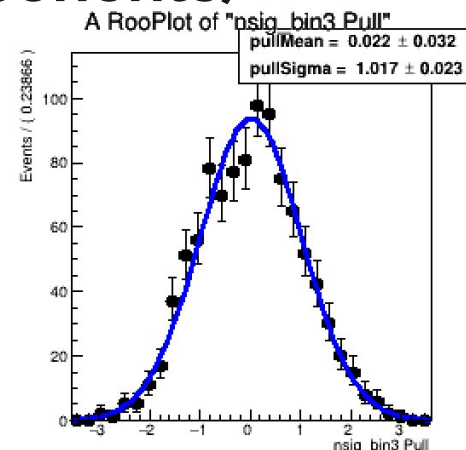
A RooPlot of "nscf\_bin2 Pull"



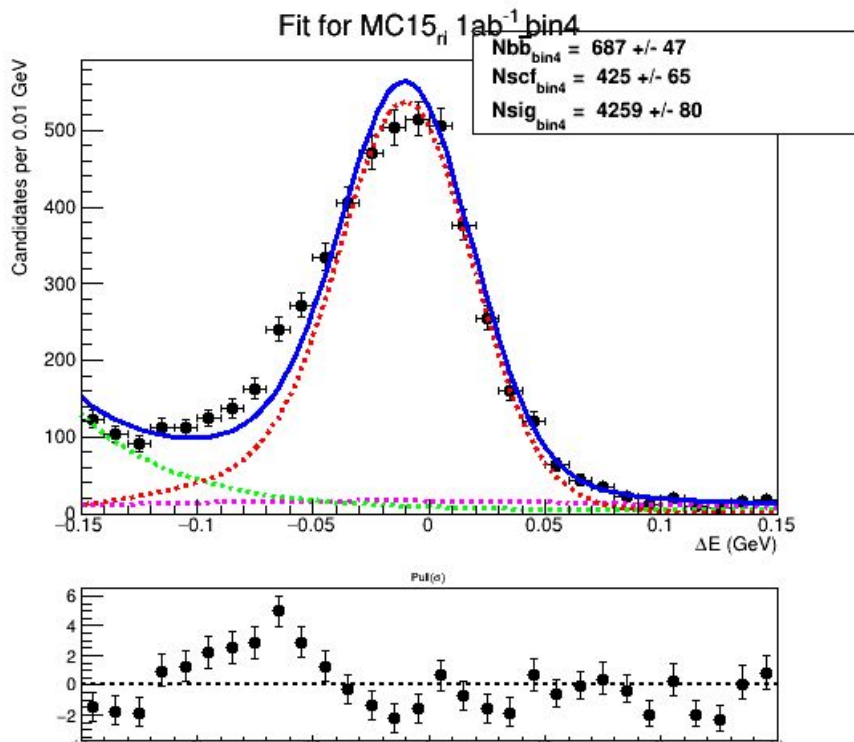
# Fit result D<sup>0</sup>ρ MC15 fits for 3 bin (all components)



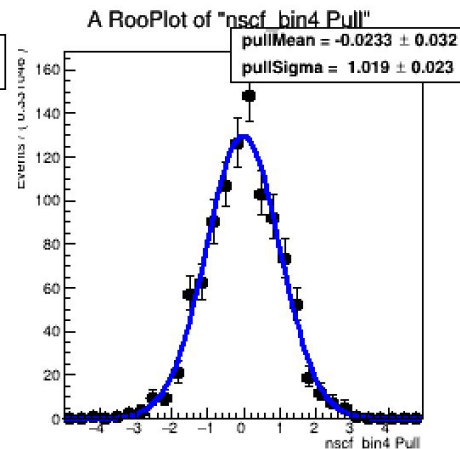
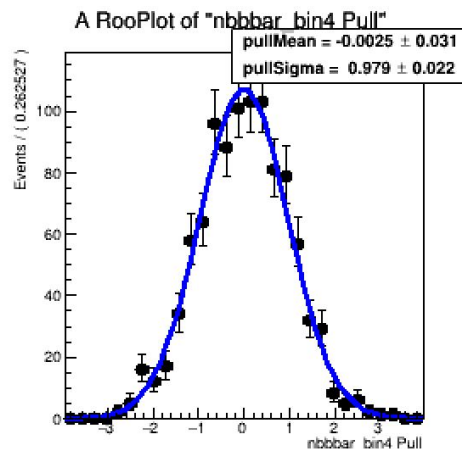
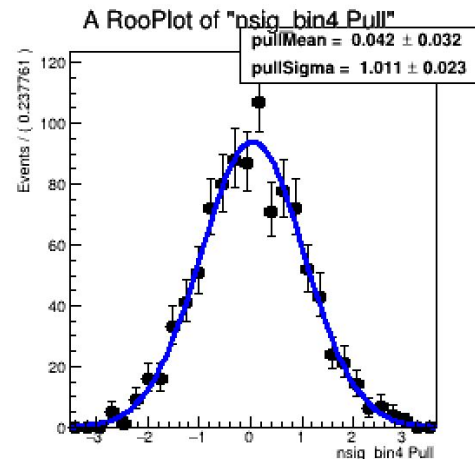
| Composition | σ          |
|-------------|------------|
| Signal      | <b>2.7</b> |
| SxF         | 0.8        |
| BB-bar      | <b>3.7</b> |



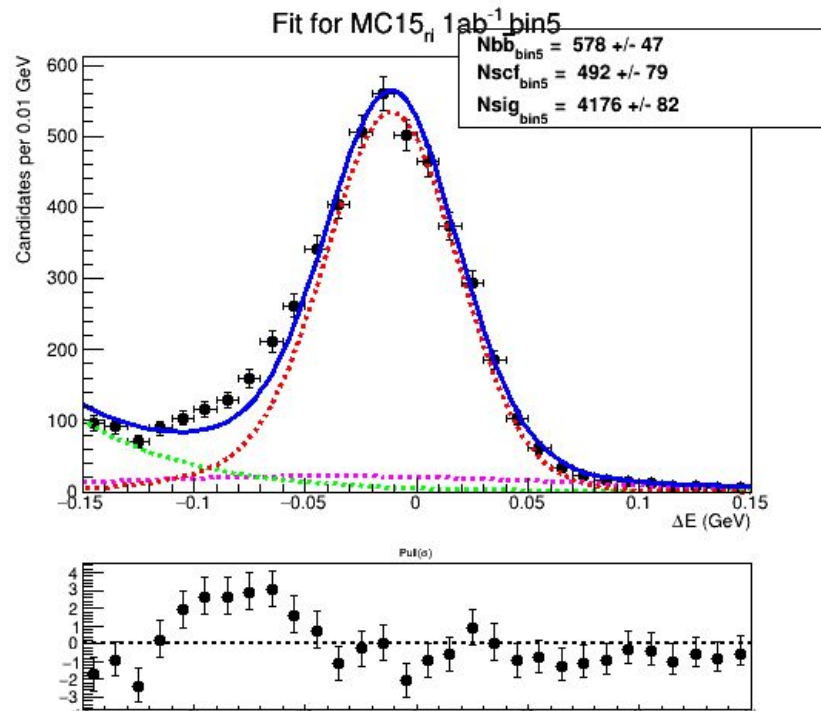
# Fit result $D^0\rho$ MC15 fits for 4 bin (all components)



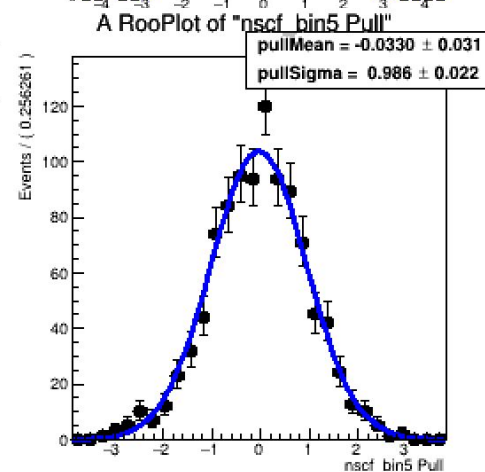
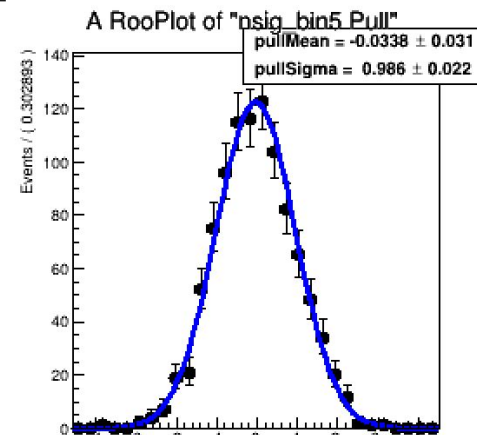
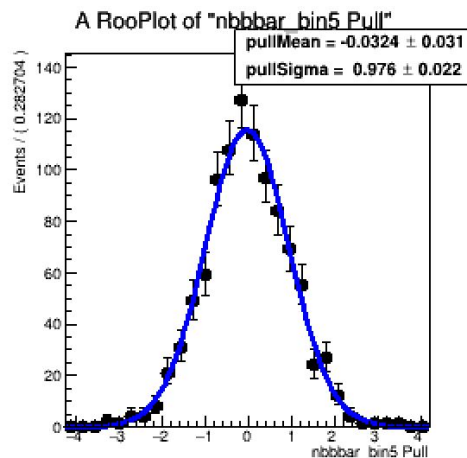
| Composition | $\sigma$ |
|-------------|----------|
| Signal      | 4.3      |
| SxF         | 2.0      |
| BB-bar      | 4.5      |



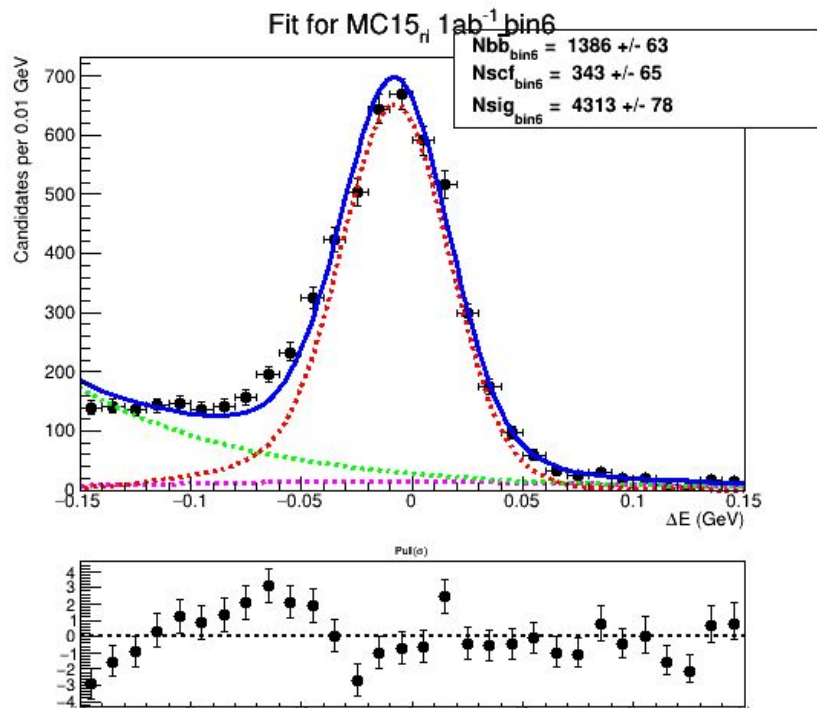
# Fit result D<sup>0</sup>ρ MC15 fits for 5 bin (all components)



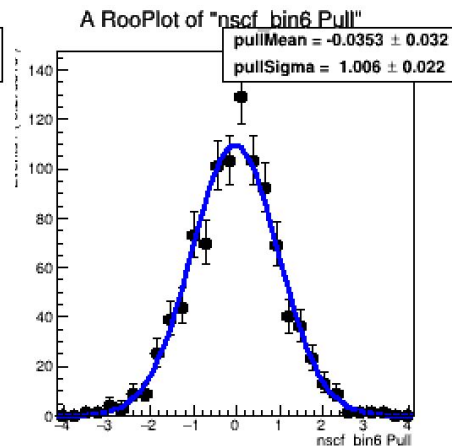
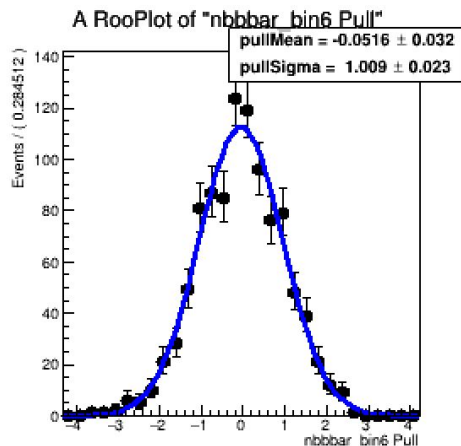
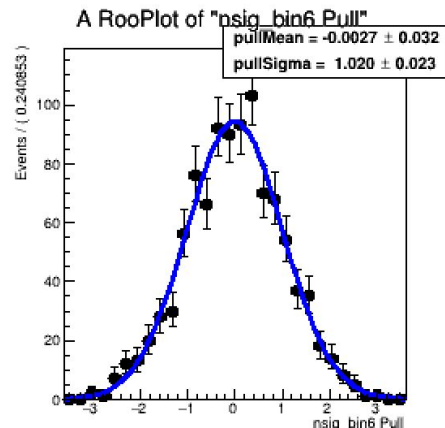
| Composition | $\sigma$ |
|-------------|----------|
| Signal      | 5.3      |
| SxF         | 3.9      |
| BB-bar      | 2.6      |



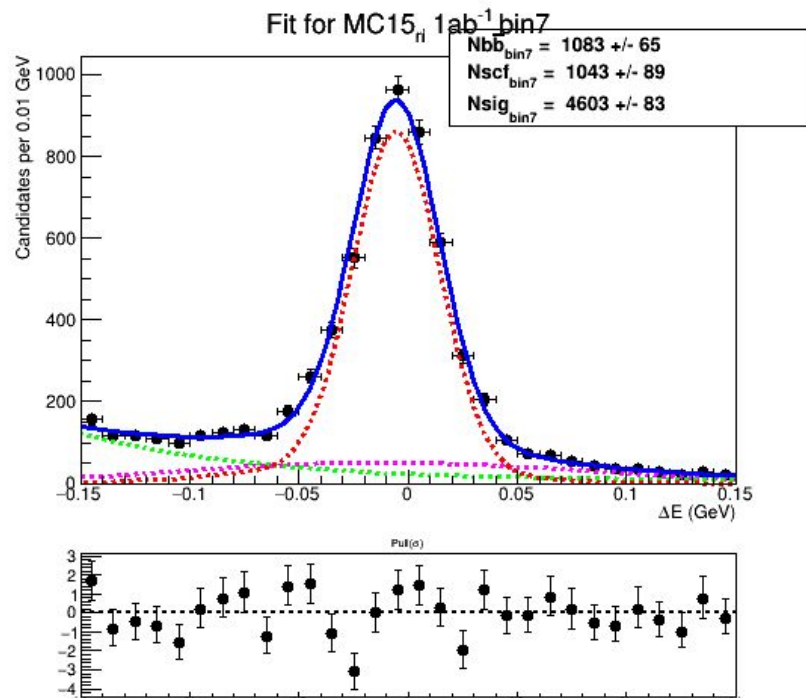
# Fit result D<sup>0</sup>ρ MC15 fits for 6 bin (all components)



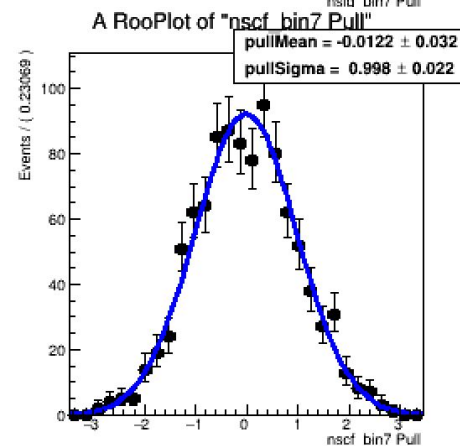
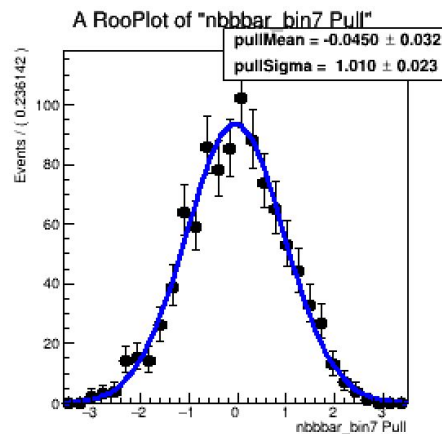
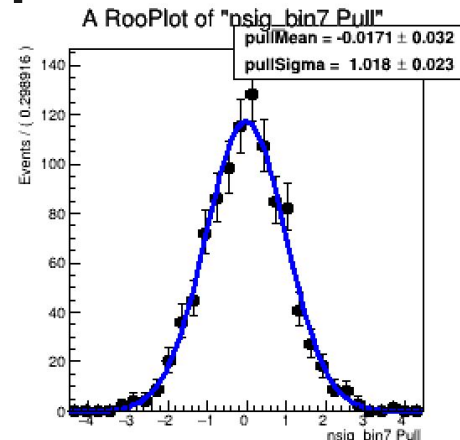
| Composition | $\sigma$   |
|-------------|------------|
| Signal      | <b>3.6</b> |
| SxF         | 1.3        |
| BB-bar      | <b>3.1</b> |



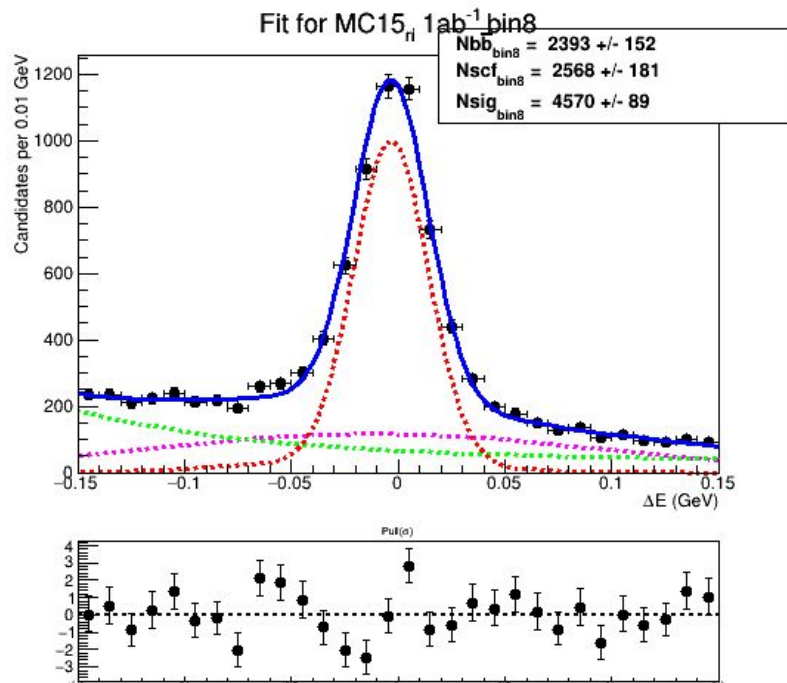
# Fit result D<sup>0</sup>ρ MC15 fits for 7 bin (all components)



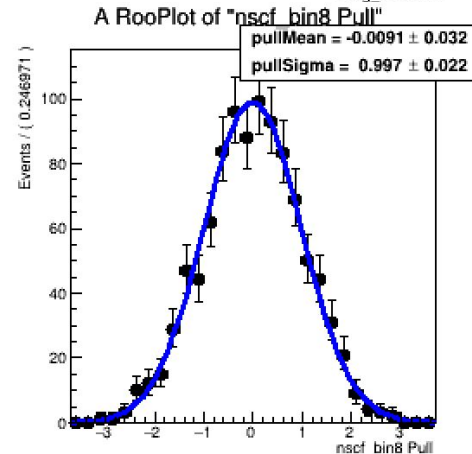
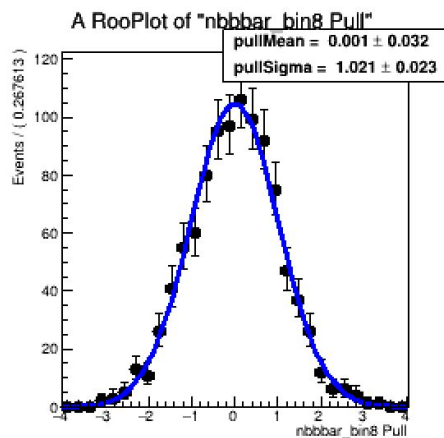
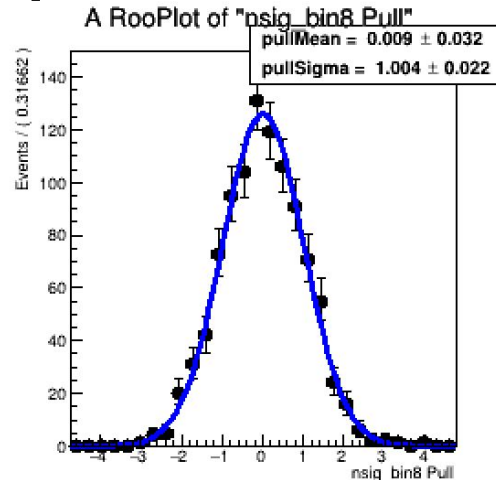
| Composition | σ   |
|-------------|-----|
| Signal      | 0.1 |
| SxF         | 1.0 |
| BB-bar      | 1.2 |



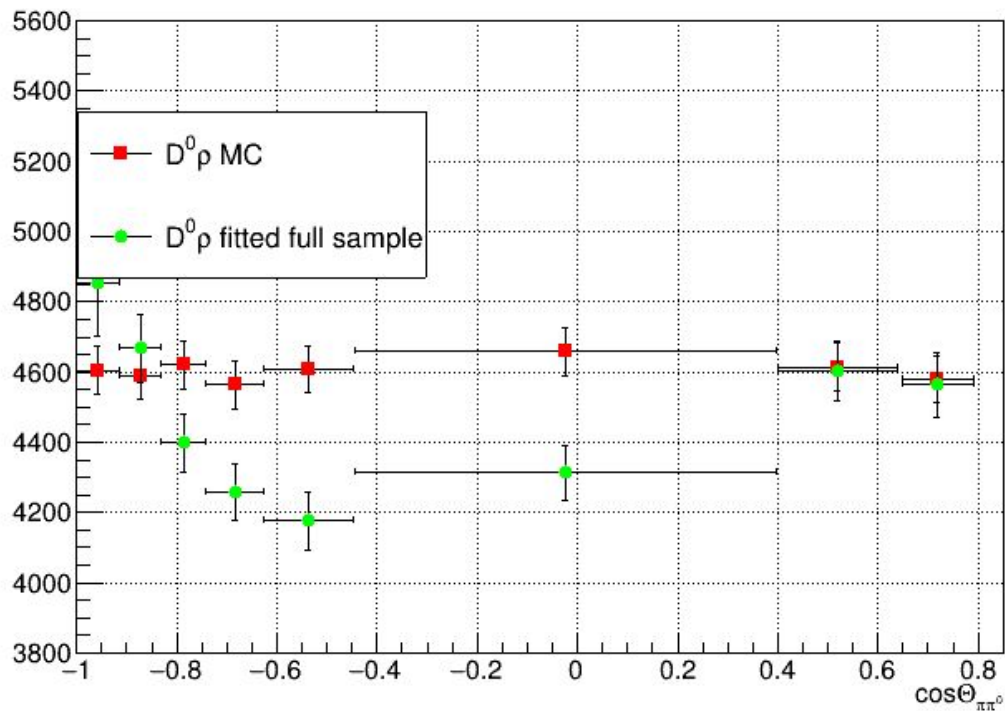
# Fit result $D^0\rho$ MC15 fits for 8 bin (all components)



| Composition | $\sigma$ |
|-------------|----------|
| Signal      | 0.1      |
| SxF         | 0.8      |
| BB-bar      | 0.6      |



# Comparison of signal Yields when fitted only signal MC vs full MC sample



# $\pi^0$ selection optimised with photonMVA weights

E\_forward > 60 MeV

E\_barrel > 50 MeV

E\_backward > 100 MeV

clusterNHits > 1.5

|clusterTiming| < 200 ns

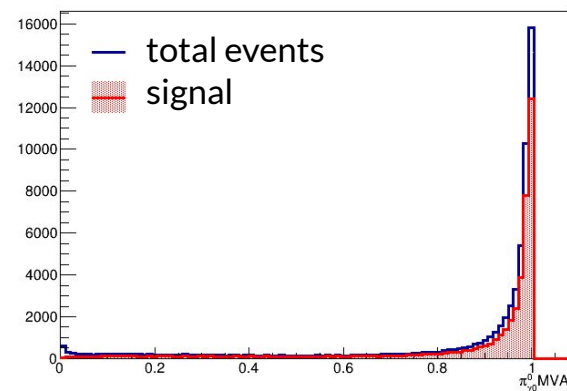
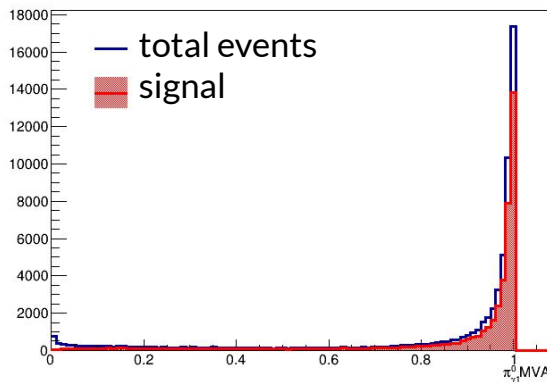
**PhotonMVA > 0.1**

118 MeV < M\_pi0 < 151 MeV

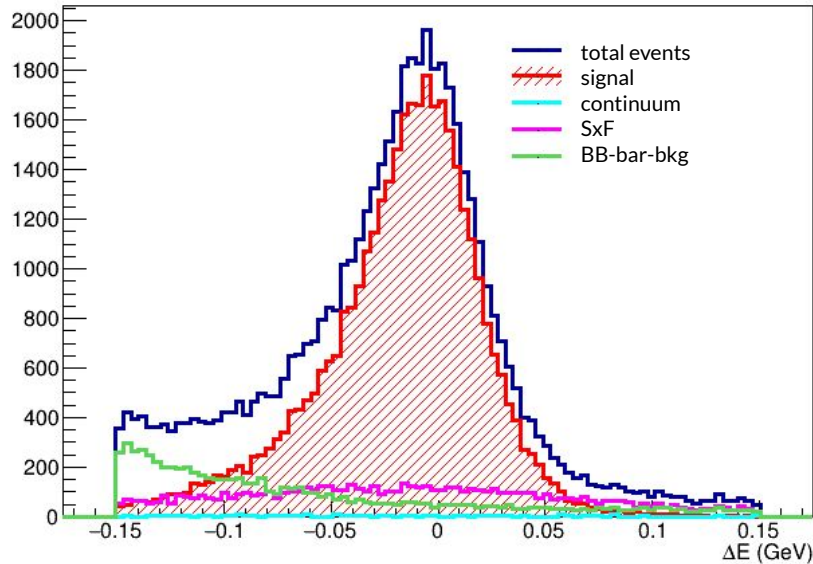
P\_pi0 > 240 MeV

daughterAngle < 1.0

|daughterDiffOfPhi| < 2.2



# $D^0\rho$ composition MC15<sub>ri</sub> 1 ab<sup>-1</sup> with $\pi^0$ selection



| Composition  | Nevents | Fraction |
|--------------|---------|----------|
| Signal       | 42815   | 0.75     |
| Continuum    | 347     | 0.006    |
| SxF          | 6854    | 0.12     |
| BB-bar bkg   | 7421    | 0.13     |
| Total events | 57536   | 1.0      |



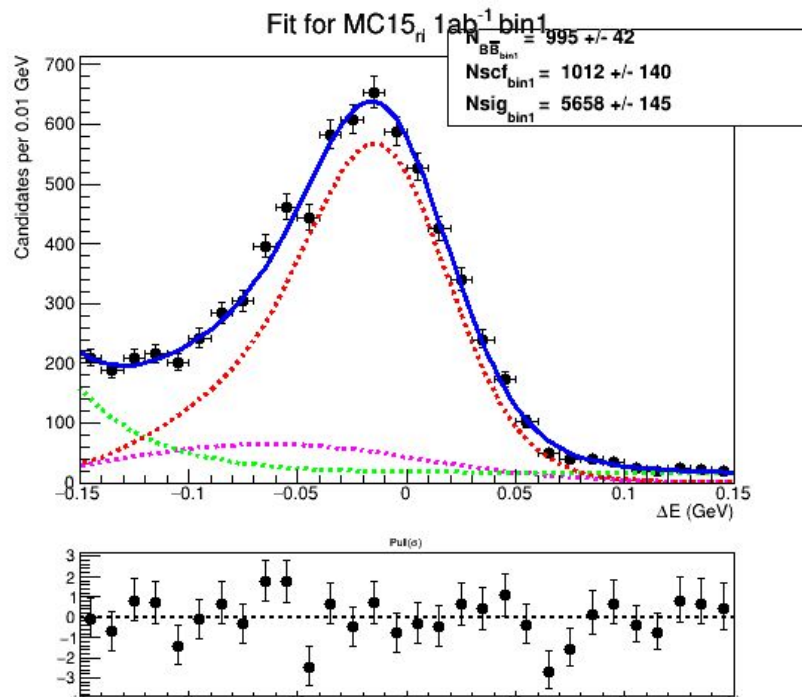
**Update after  $\pi^0$  selection applied**

# True components wrt each bin MC15 after $\pi^0$ selection

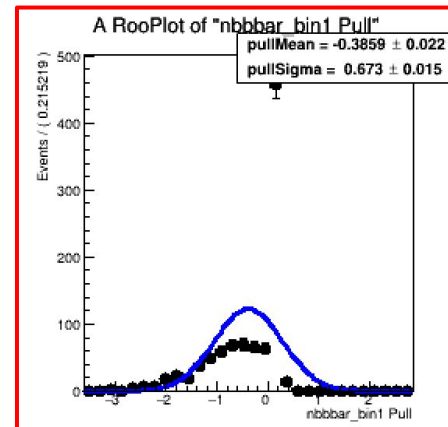
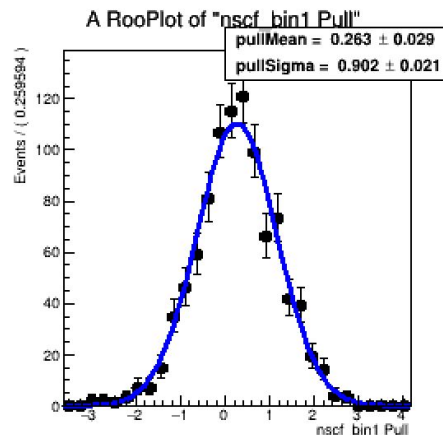
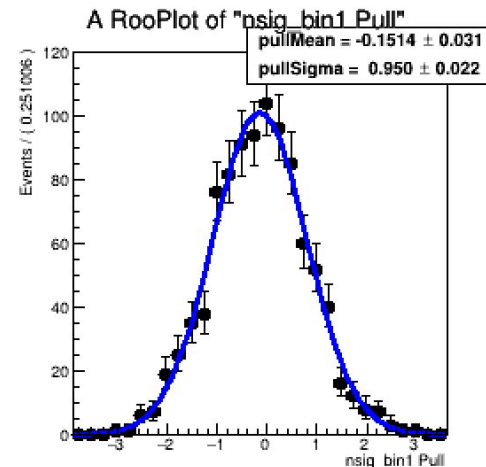


|       | $\cos\Theta_\rho$      | True Sig | Self x-feed | BB-bar |
|-------|------------------------|----------|-------------|--------|
| Bin 1 | $< - 0.916$            | 5327     | 1551        | 763    |
| Bin 2 | $- 0.916 \div - 0.837$ | 5315     | 923         | 583    |
| Bin 3 | $- 0.837 \div - 0.751$ | 5351     | 580         | 591    |
| Bin 4 | $- 0.751 \div - 0.64$  | 5347     | 317         | 573    |
| Bin 5 | $- 0.64 \div - 0.472$  | 5368     | 210         | 542    |
| Bin 6 | $- 0.472 \div 0.368$   | 5353     | 232         | 1313   |
| Bin 7 | $0.368 \div 0.63$      | 5362     | 804         | 1220   |
| Bin 8 | $0.63 \div 0.8$        | 5392     | 2237        | 2256   |

# Fit result D<sup>0</sup>ρ MC15 fits for 1 bin (all components)

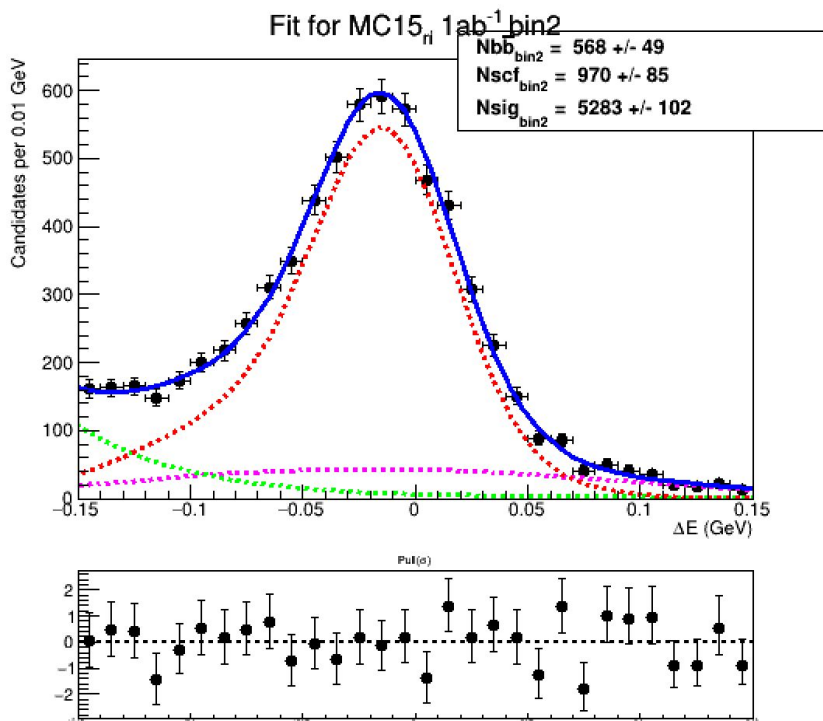


| Composition | $\sigma$    |
|-------------|-------------|
| Signal      | <b>2.3</b>  |
| SxF         | <b>-3.9</b> |
| BB-bar      | <b>5.5</b>  |



| PARAMETER | CORRELATION COEFFICIENTS |        |        |        |
|-----------|--------------------------|--------|--------|--------|
| NO.       | GLOBAL                   | 1      | 2      | 3      |
| 1         | 0.22464                  | 1.000  | 0.200  | -0.102 |
| 2         | 0.81903                  | 0.200  | 1.000  | -0.810 |
| 3         | 0.81282                  | -0.102 | -0.810 | 1.000  |

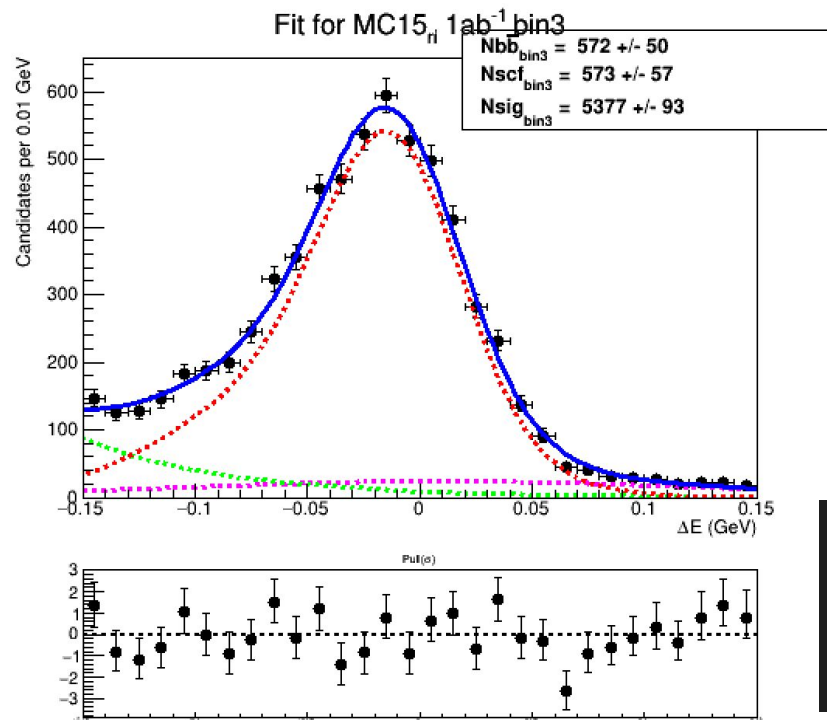
# Fit result D<sup>0</sup>ρ MC15 fits for 2 bin (all components)



| Composition | $\sigma$    |
|-------------|-------------|
| Signal      | <b>0.3</b>  |
| SxF         | <b>0.6</b>  |
| BB-bar      | <b>-0.3</b> |

| PARAMETER CORRELATION COEFFICIENTS |         |       |        |        |
|------------------------------------|---------|-------|--------|--------|
| NO.                                | GLOBAL  | 1     | 2      | 3      |
| 1                                  | 0.47784 | 1.000 | 0.352  | 0.076  |
| 2                                  | 0.67703 | 0.352 | 1.000  | -0.550 |
| 3                                  | 0.62081 | 0.076 | -0.550 | 1.000  |

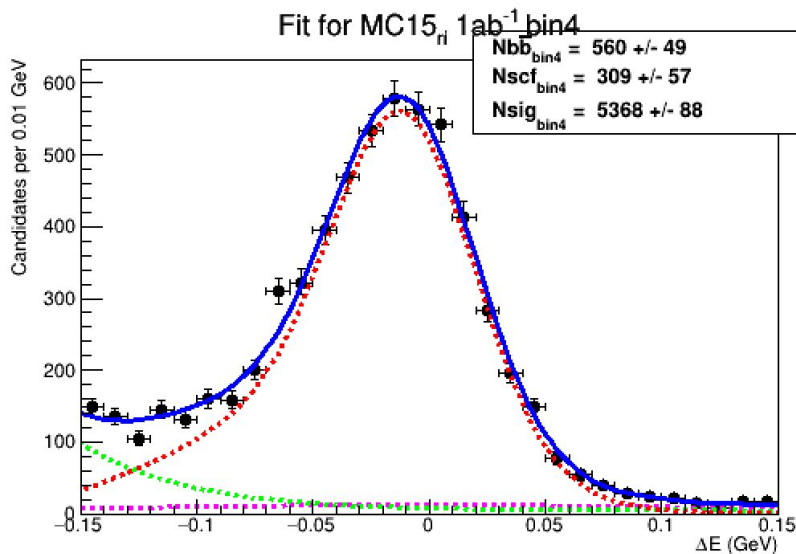
# Fit result D<sup>0</sup>ρ MC15 fits for 3 bin (all components)



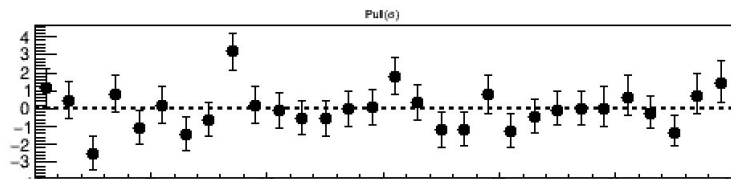
| Composition | σ           |
|-------------|-------------|
| Signal      | <b>0.3</b>  |
| SxF         | <b>-0.1</b> |
| BB-bar      | <b>-0.4</b> |

| PARAMETER CORRELATION COEFFICIENTS |         |       |        |        |
|------------------------------------|---------|-------|--------|--------|
| NO.                                | GLOBAL  | 1     | 2      | 3      |
| 1                                  | 0.45721 | 1.000 | 0.247  | 0.265  |
| 2                                  | 0.51801 | 0.247 | 1.000  | -0.374 |
| 3                                  | 0.52503 | 0.265 | -0.374 | 1.000  |

# Fit result D<sup>0</sup>ρ MC15 fits for 4 bin (all components)

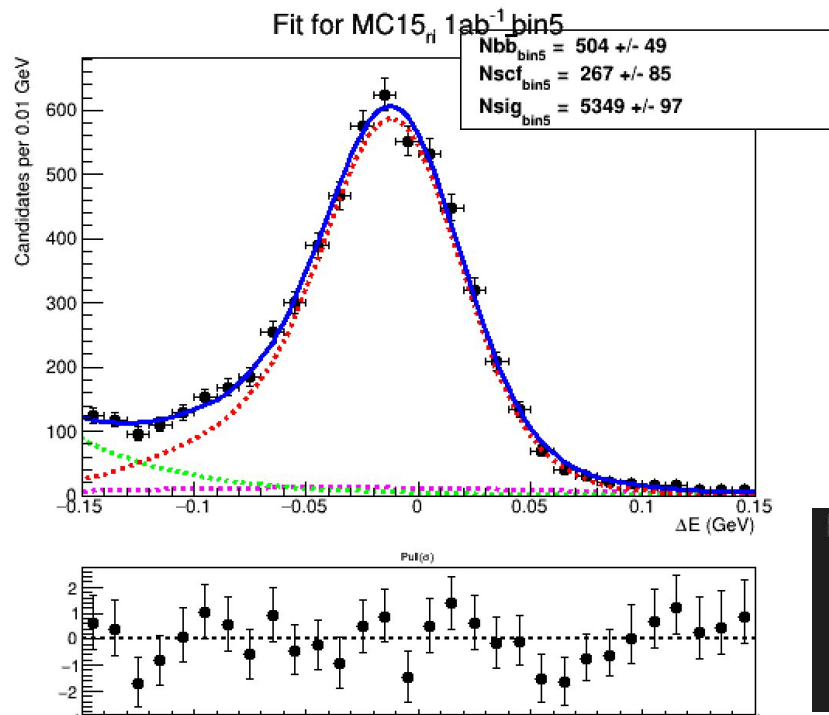


| Composition | $\sigma$    |
|-------------|-------------|
| Signal      | <b>0.2</b>  |
| SxF         | <b>-0.1</b> |
| BB-bar      | <b>-0.3</b> |



| PARAMETER NO. | CORRELATION COEFFICIENTS |        |        |       |
|---------------|--------------------------|--------|--------|-------|
|               | GLOBAL                   | 1      | 2      | 3     |
| 1             | 0.53903                  | 1.000  | -0.439 | 0.143 |
| 2             | 0.60133                  | -0.439 | 1.000  | 0.344 |
| 3             | 0.47468                  | 0.143  | 0.344  | 1.000 |

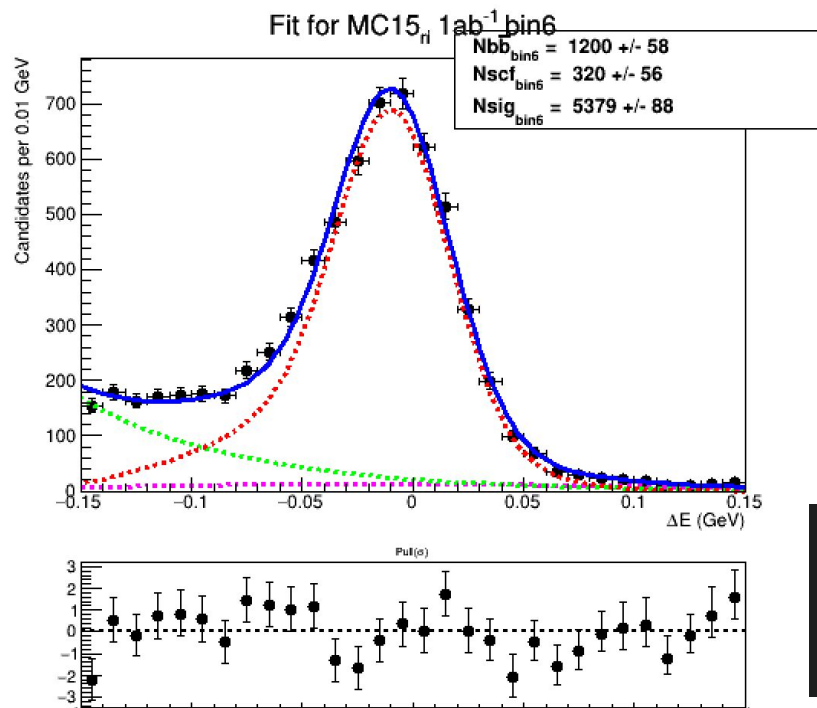
# Fit result D<sup>0</sup>ρ MC15 fits for 5 bin (all components)



| Composition | $\sigma$    |
|-------------|-------------|
| Signal      | <b>-0.2</b> |
| SxF         | <b>0.7</b>  |
| BB-bar      | <b>-0.8</b> |

| PARAMETER | CORRELATION COEFFICIENTS |        |        |        |
|-----------|--------------------------|--------|--------|--------|
| NO.       | GLOBAL                   | 1      | 2      | 3      |
| 1         | 0.62351                  | 1.000  | 0.568  | -0.103 |
| 2         | 0.75747                  | 0.568  | 1.000  | -0.557 |
| 3         | 0.61414                  | -0.103 | -0.557 | 1.000  |

# Fit result D<sup>0</sup>ρ MC15 fits for 6 bin (all components)

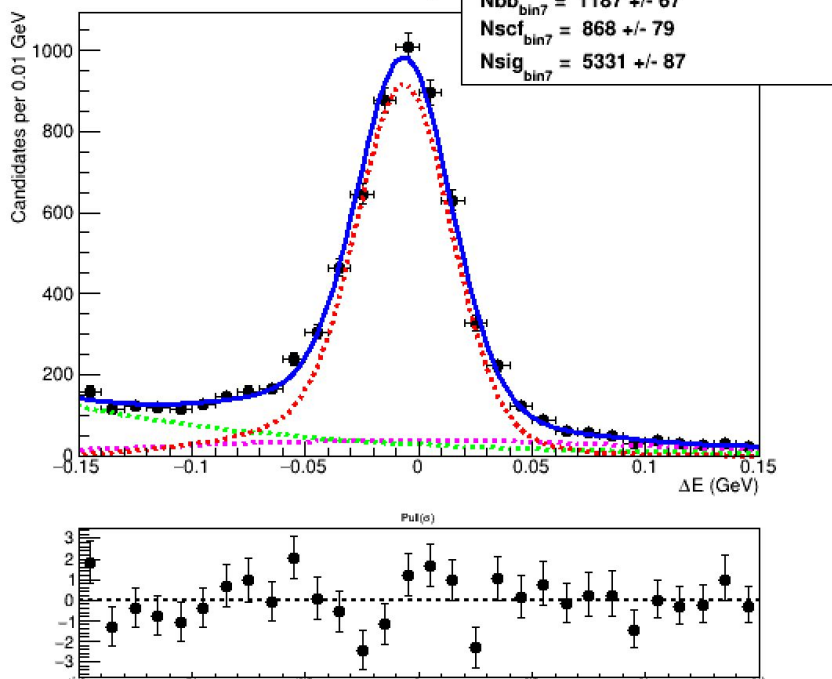


| Composition | $\sigma$ |
|-------------|----------|
| Signal      | 0.3      |
| SxF         | 1.6      |
| BB-bar      | -1.9     |

| PARAMETER NO. | CORRELATION COEFFICIENTS |        |        |        |
|---------------|--------------------------|--------|--------|--------|
|               | GLOBAL                   | 1      | 2      | 3      |
| 1             | 0.50695                  | 1.000  | -0.398 | -0.177 |
| 2             | 0.55247                  | -0.398 | 1.000  | -0.307 |
| 3             | 0.44724                  | -0.177 | -0.307 | 1.000  |

# Fit result $D^0\rho$ MC15 fits for 7 bin (all components)

Fit for MC15, 1ab<sup>-1</sup> bin7

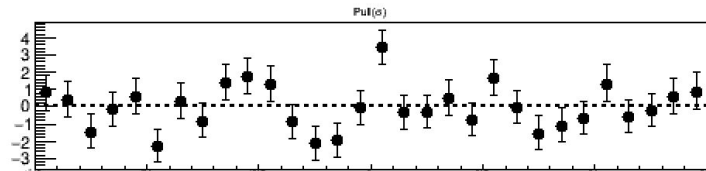
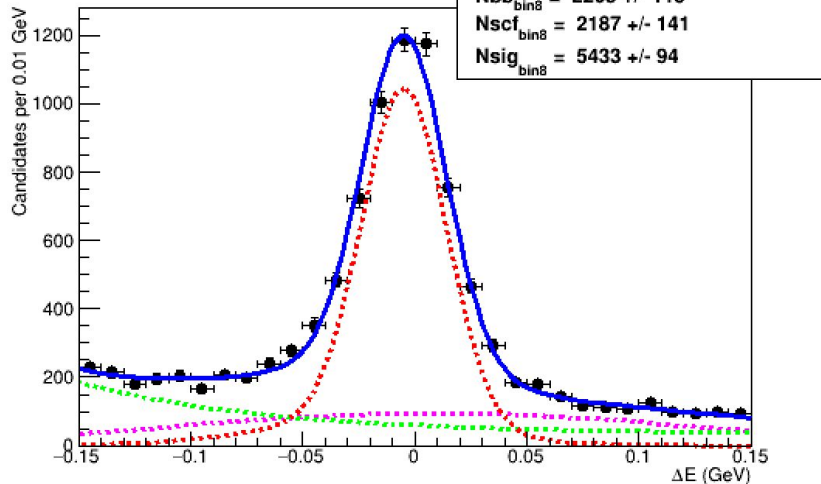


| Composition | $\sigma$ |
|-------------|----------|
| Signal      | -0.4     |
| SxF         | 0.8      |
| BB-bar      | -0.5     |

| PARAMETER CORRELATION COEFFICIENTS |         |        |        |        |
|------------------------------------|---------|--------|--------|--------|
| NO.                                | GLOBAL  | 1      | 2      | 3      |
| 1                                  | 0.63995 | 1.000  | -0.602 | -0.013 |
| 2                                  | 0.68558 | -0.602 | 1.000  | -0.320 |
| 3                                  | 0.41129 | -0.013 | -0.320 | 1.000  |

# Fit result $D^0\rho$ MC15 fits for 8 bin (all components)

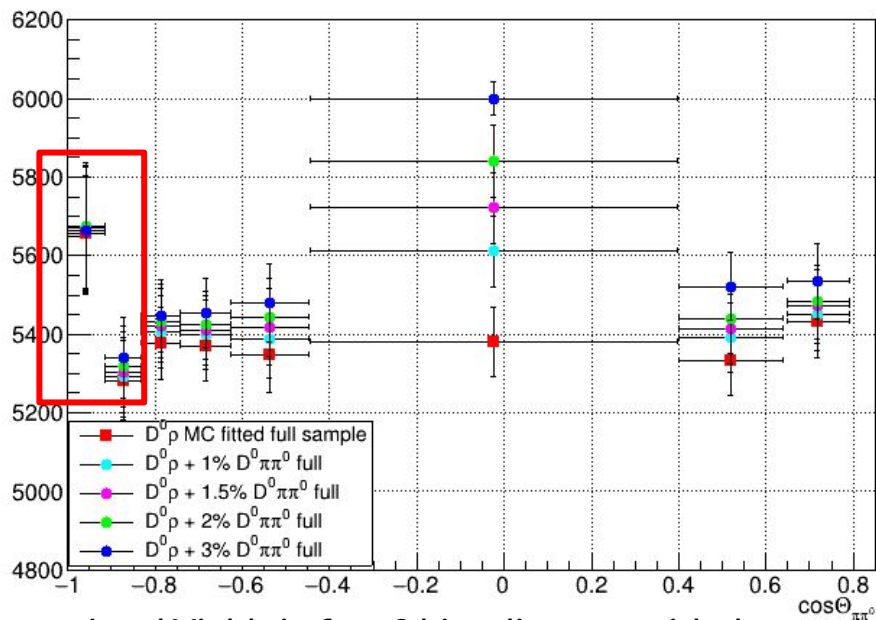
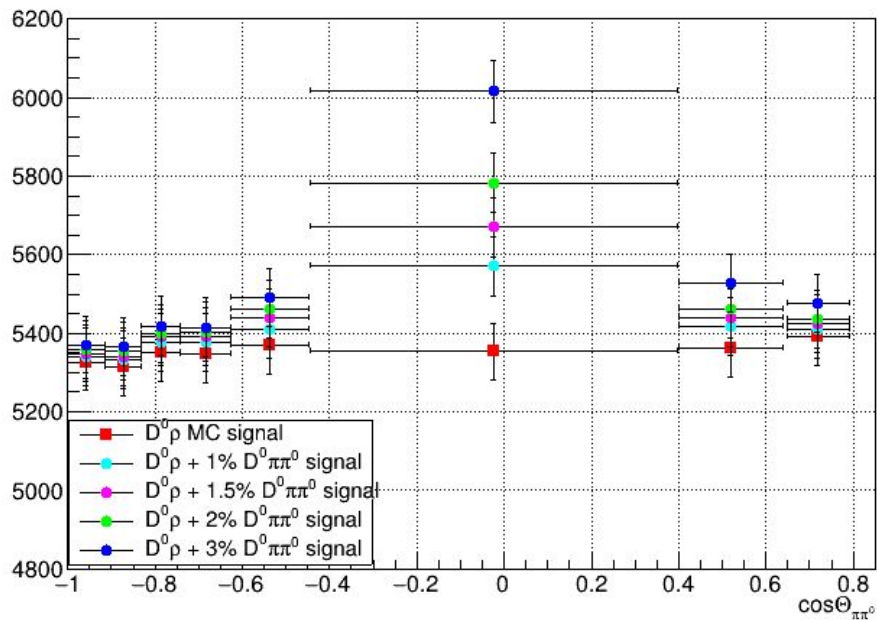
Fit for MC15,  $1\text{ab}^{-1}$  bin8



| Composition | $\sigma$    |
|-------------|-------------|
| Signal      | <b>0.4</b>  |
| SxF         | <b>-0.4</b> |
| BB-bar      | <b>0.1</b>  |

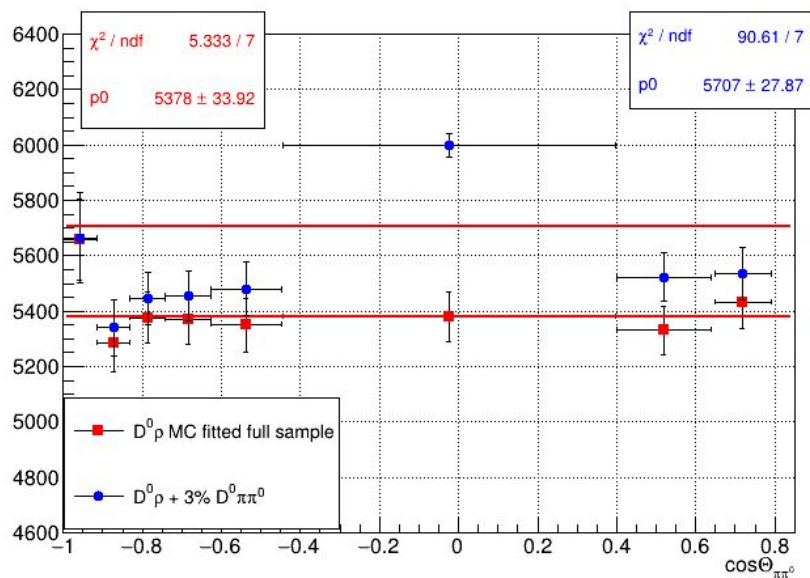
| PARAMETER |         | CORRELATION COEFFICIENTS |        |        |
|-----------|---------|--------------------------|--------|--------|
| NO.       | GLOBAL  | 1                        | 2      | 3      |
| 1         | 0.79929 | 1.000                    | -0.781 | 0.110  |
| 2         | 0.82379 | -0.781                   | 1.000  | -0.348 |
| 3         | 0.43287 | 0.110                    | -0.348 | 1.000  |

# Comparison of signal Yields when fitted only signal MC vs full MC sample with $\pi^0$ selection applied

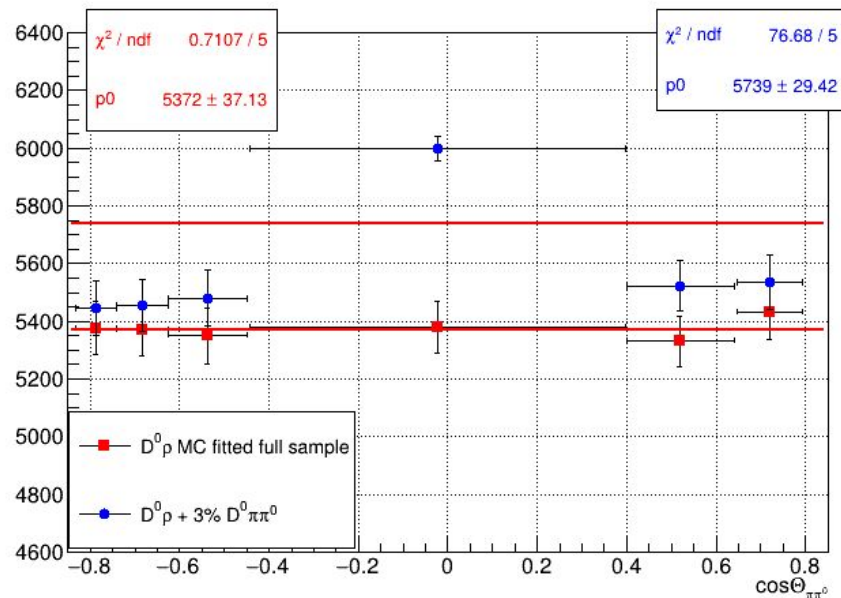


signal Yields in first 2 bins disagree with the result for signal only fit (left)

# Comparison of signal Yields when fitted full MC sample with $\pi^0$ selection applied + 3% $D^0\pi\pi^0$

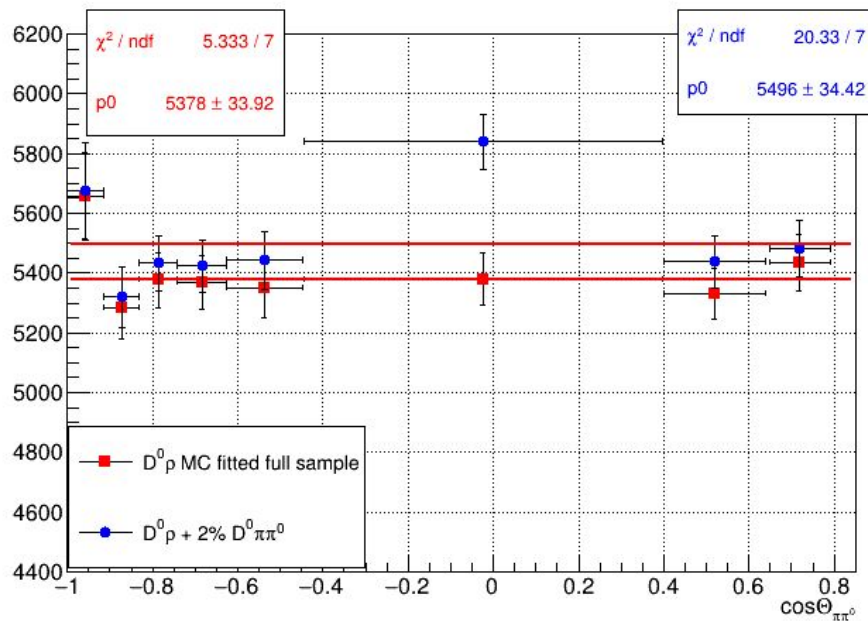


8 bins

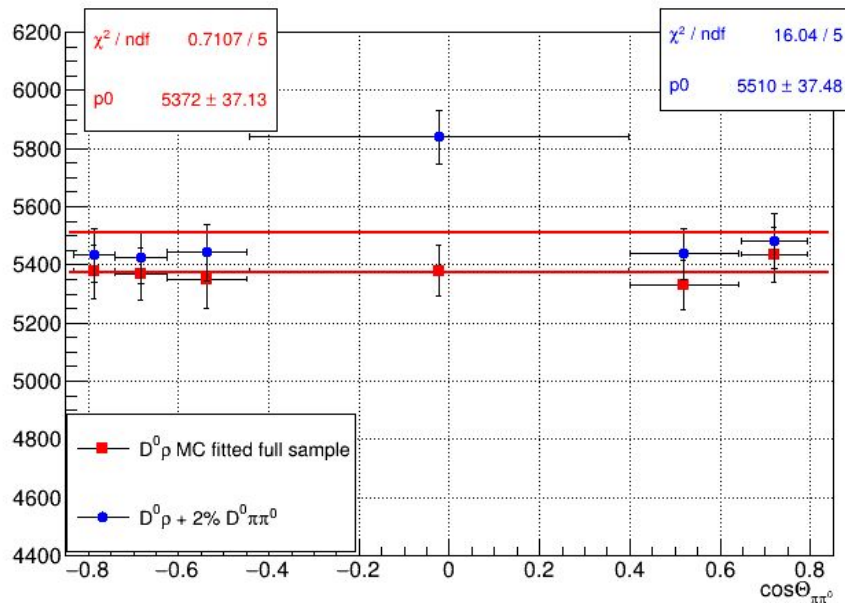


6 bins

# Comparison of signal Yields when fitted full MC sample with $\pi^0$ selection applied + 2% $D^0\pi\pi^0$

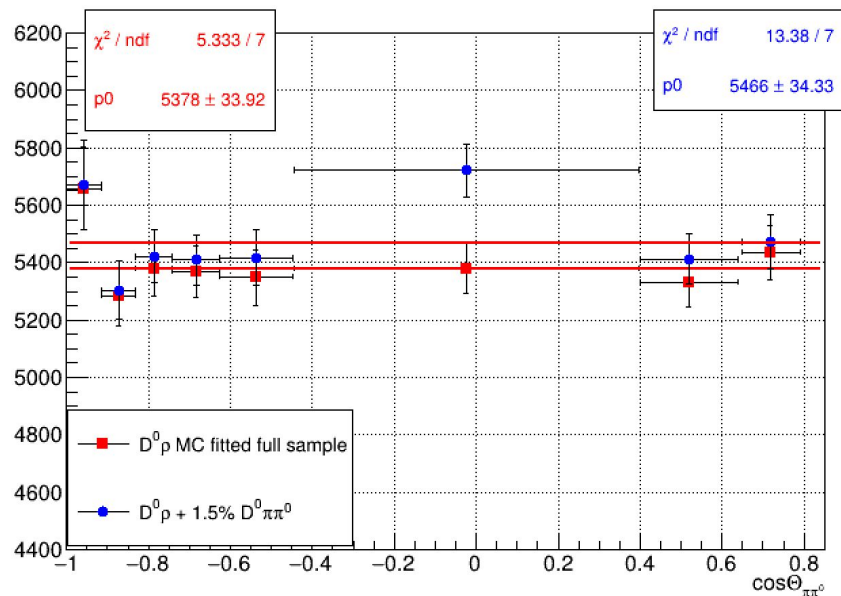


8 bins

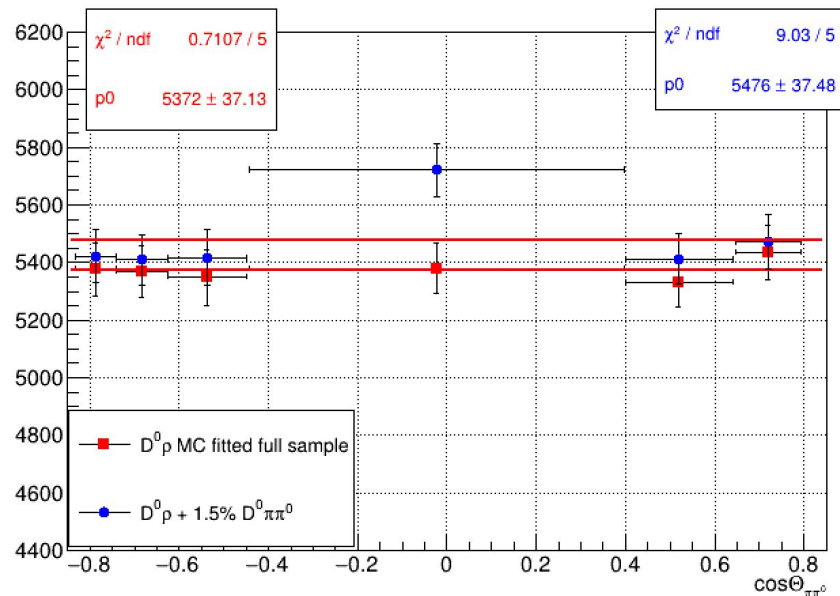


6 bins

# Comparison of signal Yields when fitted full MC sample with $\pi^0$ selection applied + 1.5% $D^0\pi\pi^0$

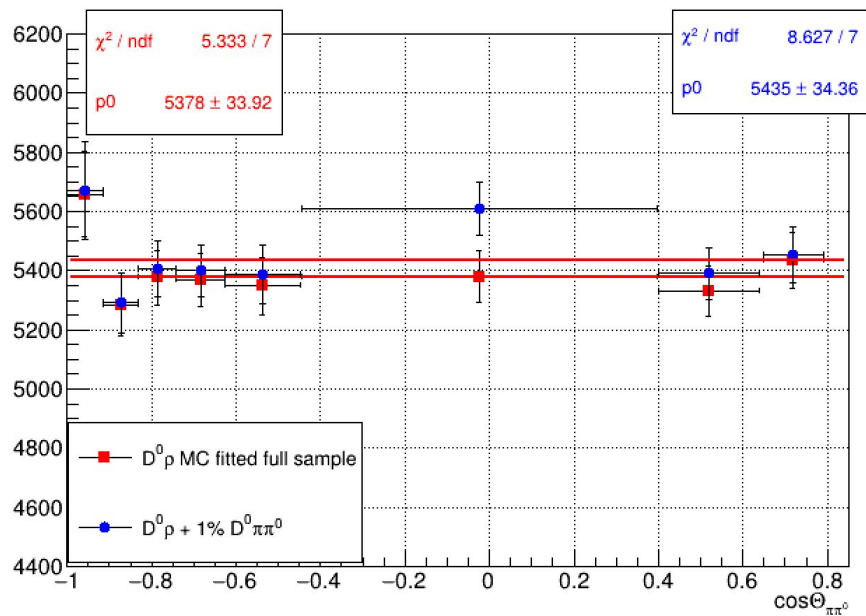


8 bins

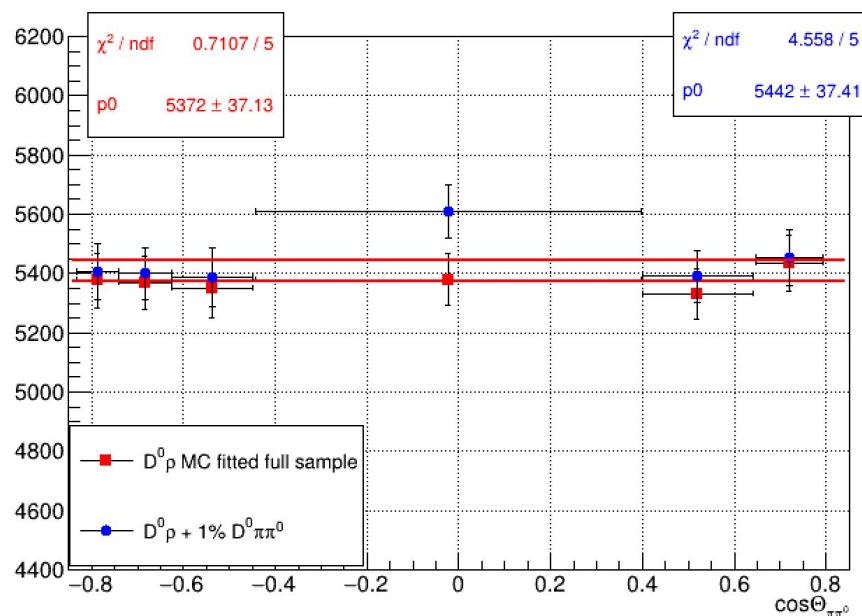


6 bins

# Comparison of signal Yields when fitted full MC sample with $\pi^0$ selection applied + 1% $D^0\pi\pi^0$



8 bins

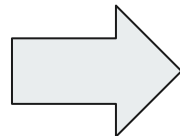


6 bins

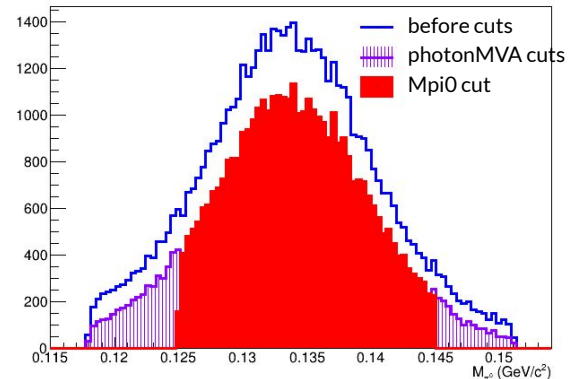
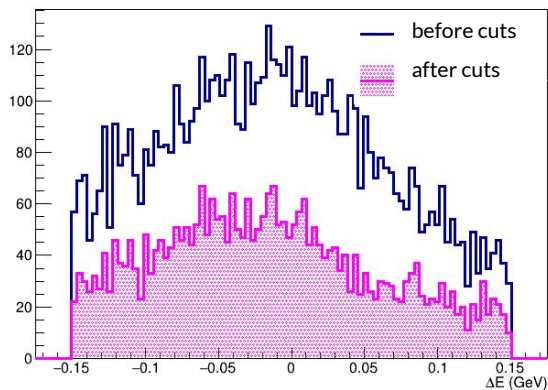
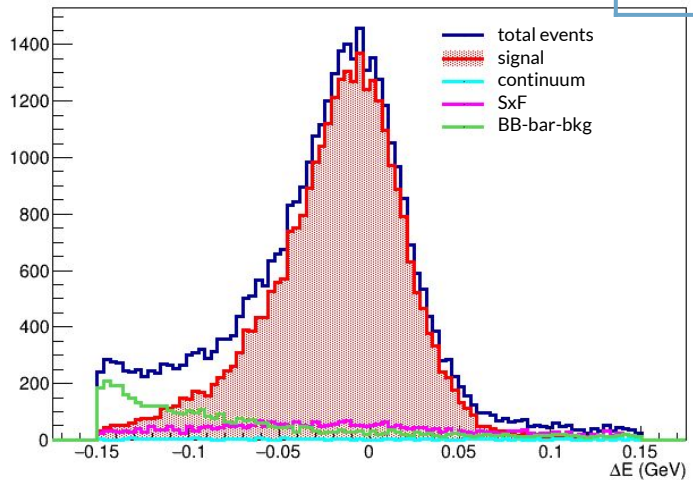
# D<sup>0</sup>ρ composition MC15<sub>ri</sub> 1 ab<sup>-1</sup> with tighter cuts π<sup>0</sup> selection

- Photon0MVA > 0.6
- Photon1MVA > 0.6
- |M<sub>π0</sub> - 0.135| < 0.01

| Composition  | Nevents | Fraction |
|--------------|---------|----------|
| Signal       | 42815   | 0.75     |
| Continuum    | 347     | 0.006    |
| SxF          | 6854    | 0.12     |
| BB-bar bkg   | 7421    | 0.13     |
| Total events | 57536   | 1.0      |

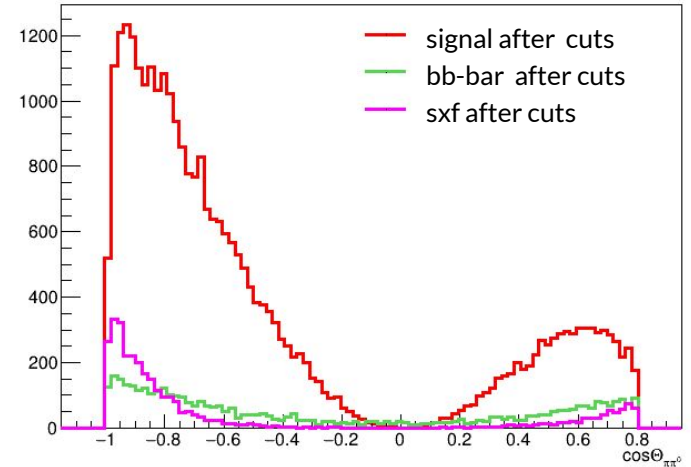
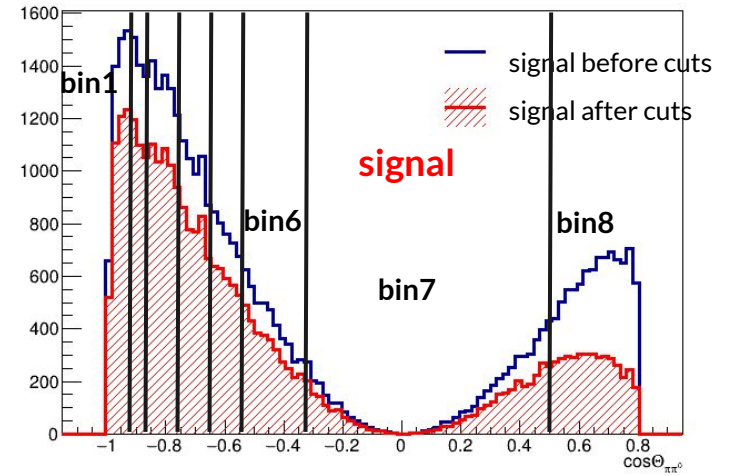


| Composition  | Nevents | Fraction |
|--------------|---------|----------|
| Signal       | 30103   | 0.8      |
| Continuum    | 184     | 0.005    |
| SxF          | 3223    | 0.09     |
| BB-bar bkg   | 4297    | 0.11     |
| Total events | 37807   | 1.0      |

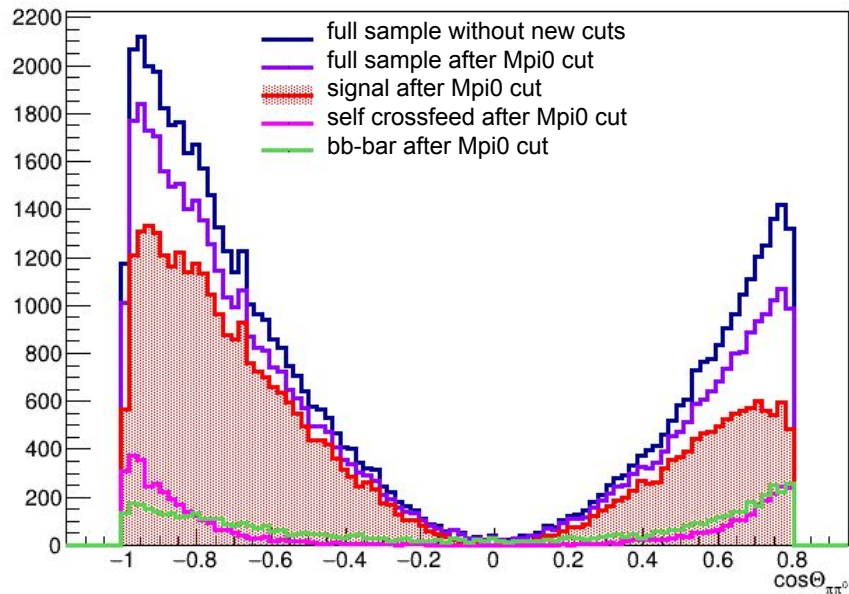
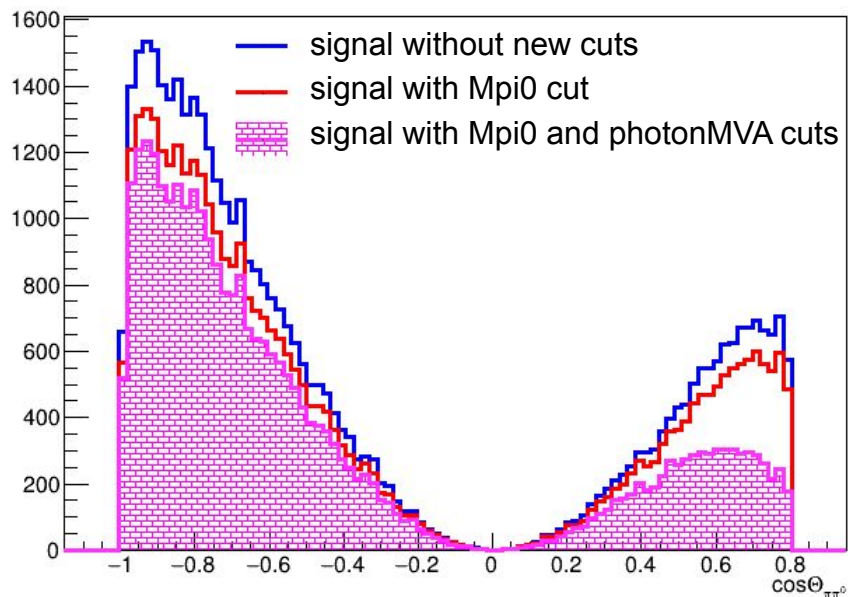


# Binning after tight $\pi^0$ cuts

|       | $\cos\Theta_\rho$    | True Sig | Self x-feed | BB-bar |
|-------|----------------------|----------|-------------|--------|
| Bin 1 | $< -0.924$           | 3770     | 1090        | 537    |
| Bin 2 | $-0.924 \div -0.854$ | 3739     | 667         | 407    |
| Bin 3 | $-0.854 \div -0.779$ | 3761     | 401         | 396    |
| Bin 4 | $-0.779 \div -0.686$ | 3766     | 248         | 379    |
| Bin 5 | $-0.686 \div -0.565$ | 3760     | 123         | 378    |
| Bin 6 | $-0.565 \div -0.346$ | 3766     | 72          | 372    |
| Bin 7 | $-0.346 \div 0.516$  | 3760     | 120         | 872    |
| Bin 8 | $0.516 \div 0.8$     | 3738     | 502         | 956    |

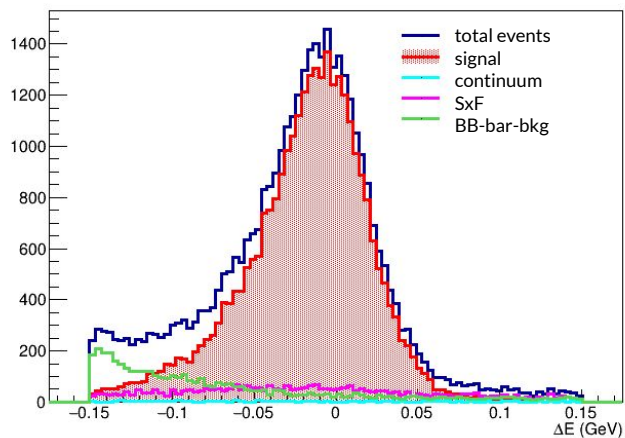


# $D^0\rho$ composition MC15<sub>ri</sub> 1 ab<sup>-1</sup> before and after $M_{\pi^0}$ cut

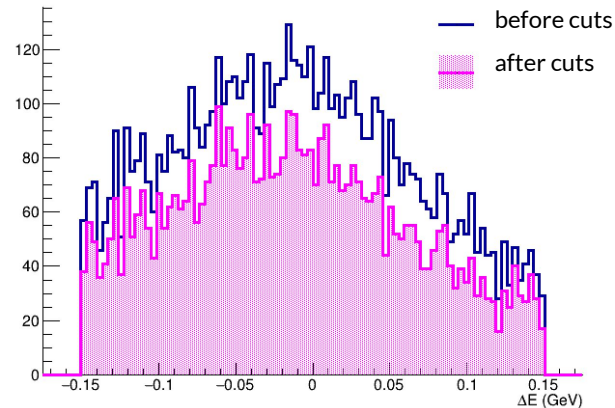


# D<sup>0</sup>ρ composition MC15<sub>ri</sub> 1 ab<sup>-1</sup> with tighter Mπ<sup>0</sup> selection

- $|M_{\pi^0} - 0.135| < 0.01$



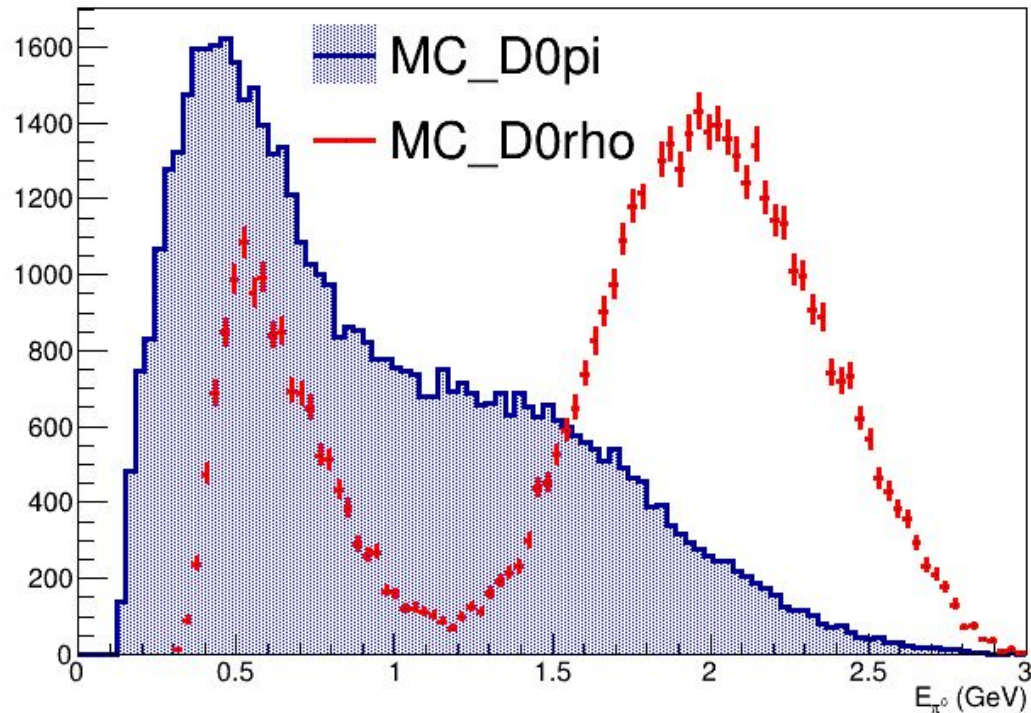
| Composition  | Nevents | Fraction |
|--------------|---------|----------|
| Signal       | 37063   | 0.76     |
| Continuum    | 272     | 0.006    |
| SxF          | 5049    | 0.10     |
| BB-bar bkg   | 6131    | 0.13     |
| Total events | 48515   | 1.0      |



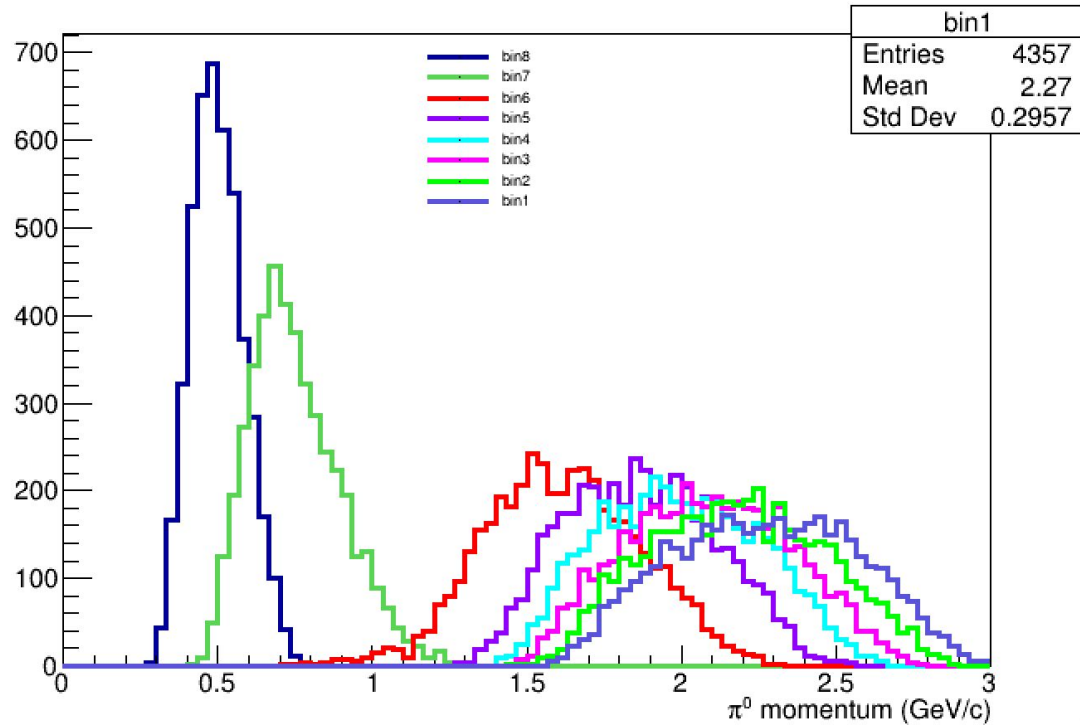


# Backup

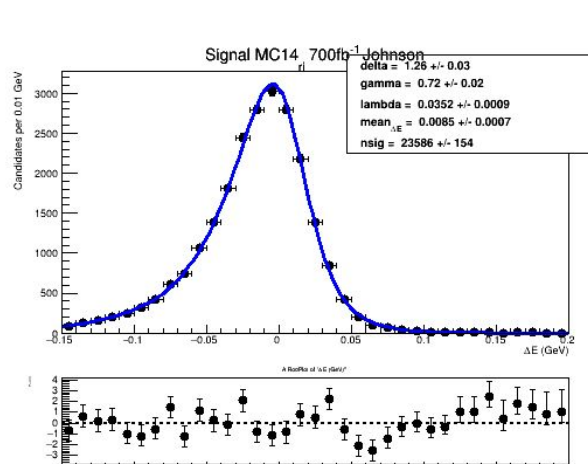
## $\pi^0$ energie for $D^0(\rightarrow K\pi\pi^0)\pi$ vs $D^0\rho$



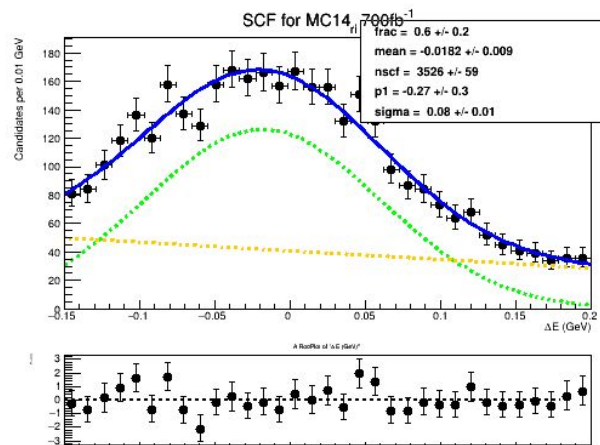
# $\pi^0$ momentum in bins of $\cos\Theta_\rho$



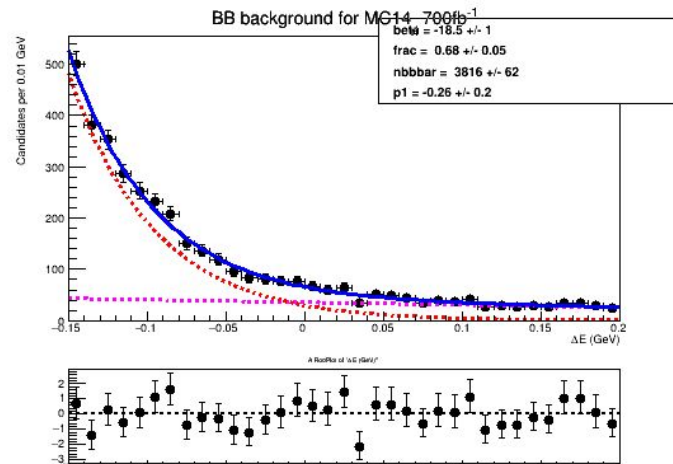
# Fitting parameters



RooJohnson

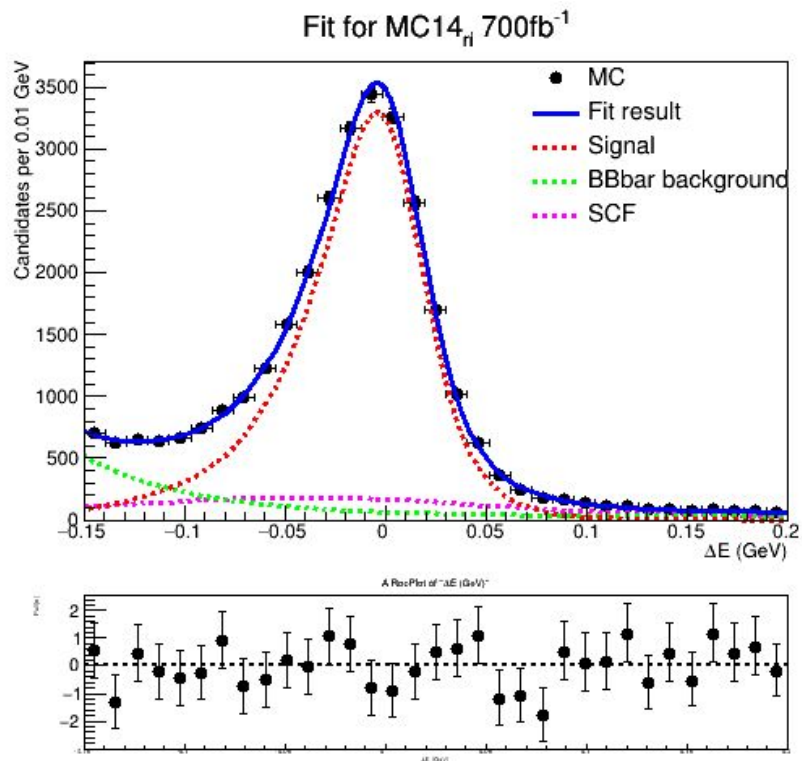


RooGaussian x  
RooChebyshev(1)



RooExponential x  
RooChebyshev(1)

# Fit result

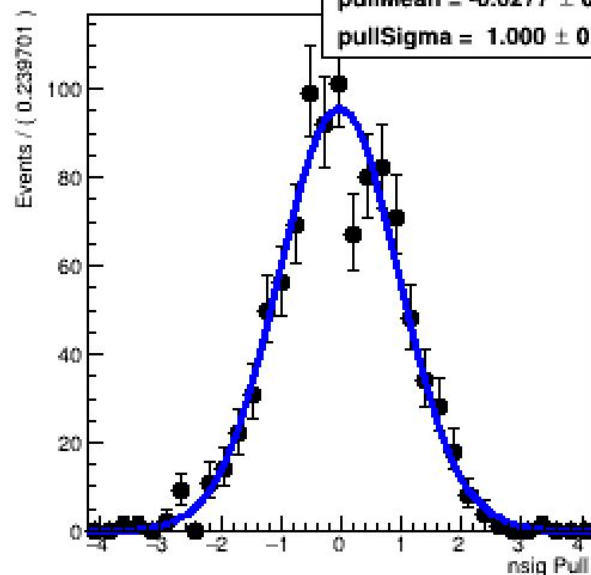


| Composition  | Nevents | Nfitted         | $\sigma$ |
|--------------|---------|-----------------|----------|
| Signal       | 23586   | $23545 \pm 233$ | 0.2      |
| Continuum    | 155     | -/-             |          |
| SCF          | 3526    | $3852 \pm 406$  | 0.8      |
| BB-bar bkg   | 3816    | $3530 \pm 270$  | 1.1      |
| Total events | 30928   | 30927           |          |

# TOY MC

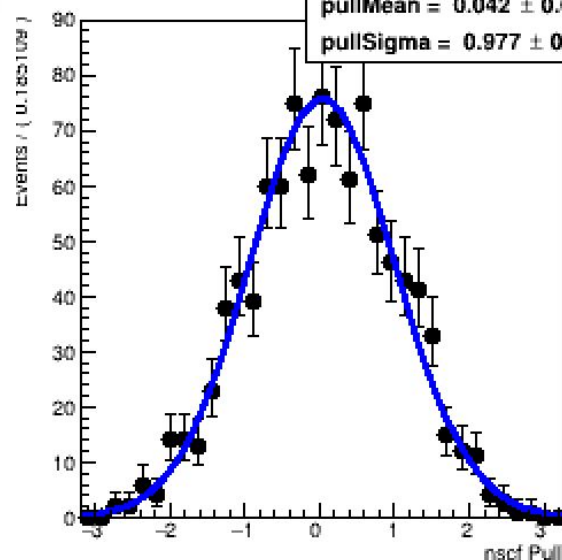
A RooPlot of "nsig Pull"

pullMean =  $-0.0277 \pm 0.032$   
pullSigma =  $1.000 \pm 0.022$



A RooPlot of "nscf Pull"

pullMean =  $0.042 \pm 0.031$   
pullSigma =  $0.977 \pm 0.022$



A RooPlot of "nbbar Pull"

pullMean =  $-0.0180 \pm 0.030$   
pullSigma =  $0.963 \pm 0.022$

